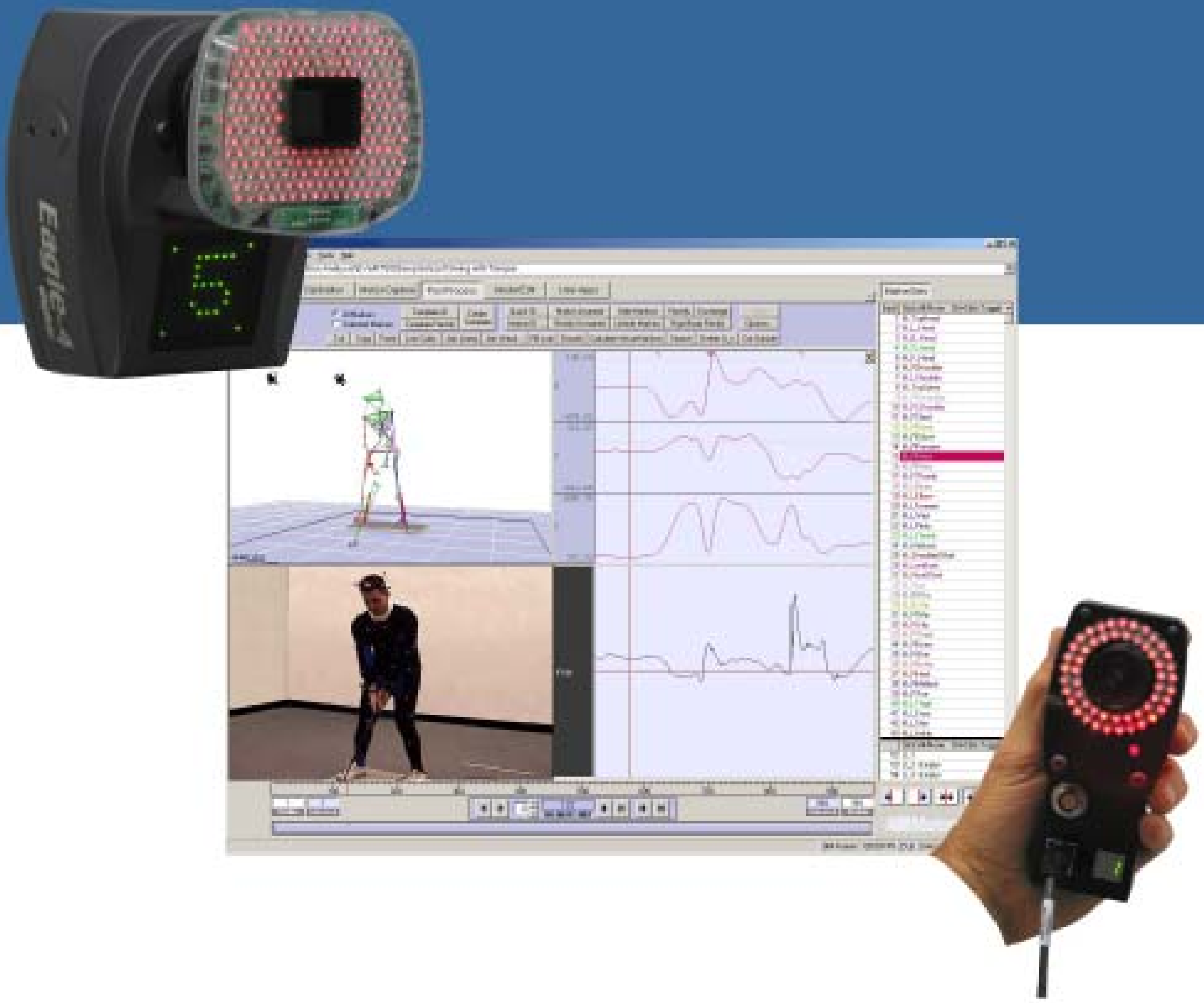
EVaRT 5.0



User's Manual

MotionAnalysis

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For further information regarding this EVaRT 5.0.3 User’s Manual or other products, please contact:

Motion Analysis Corporation
3617 Westwind Boulevard
Santa Rosa, CA 95403 USA
tel: 707.579.6500
fax: 707.526.0629
info@motionanalysis.com

P/N 656-1100-R50
www.motionanalysis.com

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Chapter 1

Introduction

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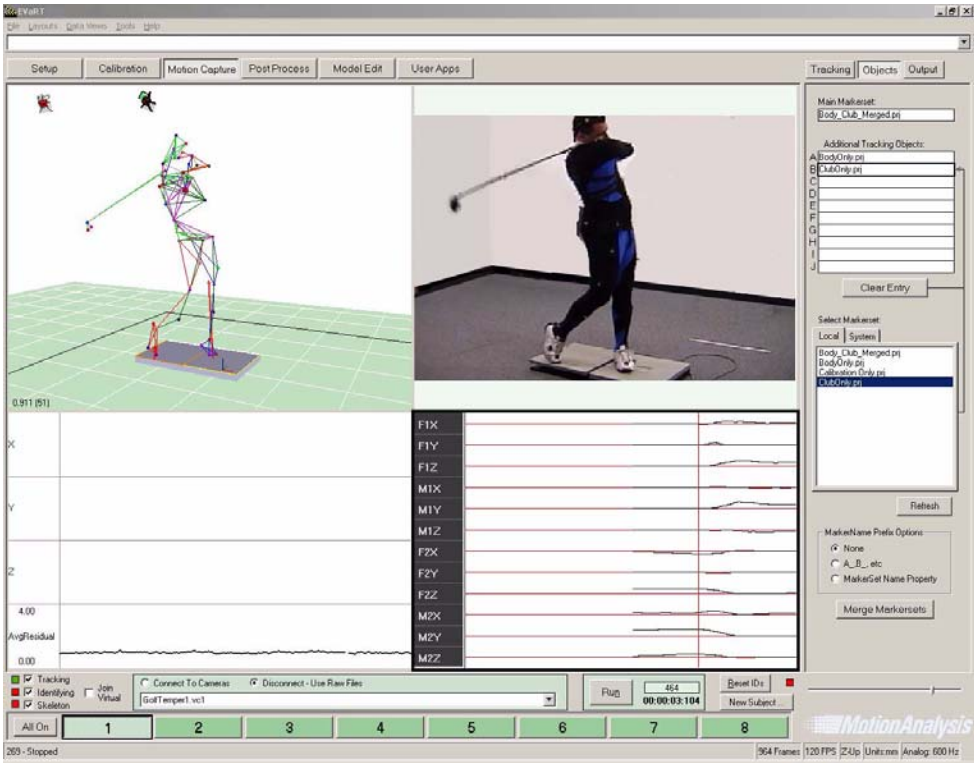
Overview

Figure 1-1. EVaRT User Interface



EVaRT
File
Layouts
Data Views
Tools
Help
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Tracking
Objects
Output
0.911 (51)
X
Y
Z
4.00
AvgResidual
0.00
F1X
F1Y
F1Z
M1X
M1Y
M1Z
F2X
F2Y
F2Z
M2X
M2Y
M2Z
Clear Entry
Refresh
Merge Markersets
Run
Reset IDs
New Subject ...
All On
1
2
3
4
5
6
7
8
MotionAnalysis

Main Markerset: Body_Club_Merged.prj

Additional Tracking Objects:
A BodyOnly.prj
B ClubOnly.prj
C
D
E
F
G
H
I
J

Select Markerset:
Local | System
Body_Club_Merged.prj
BodyOnly.prj
Calibration Only.prj
ClubOnly.prj

MarkerName Prefix Options
● None
○ A_B_, etc
○ MarkerSet Name Property

☑ Tracking
☑ Identifying
☑ Skeleton
☐ Join Virtual

○ Connect To Cameras ● Disconnect - Use Raw Files
GolfTemper1.vc1

464
00:00:03:104

269 - Stopped
964 Frames
120 FPS
Z-Up
Units:mm
Analog: 600 Hz

This instructional User's Manual provides a complete description of the **EVaRT** software and its capabilities, along with many step-by-step procedures critical to a successful motion capture project. Motion capture theory is separated from the body of this manual in the form of appendices so that the tutorial approach does not become cluttered.

EVaRT is a complete package, capable of meeting the most demanding requirements of the motion capture industry. Output is generated in real-time making **EVaRT** a suitable engine for a number of widely used 3D animation packages as well as custom applications created using the supplied Software Developers Kit (SDK). Being a real-time application, the results of a motion capture session can be viewed instantly while simultaneously saved in several file formats. In addition, you can graphically edit data with a complete suite of tools without resorting to other off-the-shelf software packages.

EVaRT handles image data from systems comprised of up to 32 cameras. System setup and calibration is fast and simple with immediate feedback and a high degree of accuracy and precision. Motion capture sessions are managed using new directory and file access tools and the motion data generated is of the highest quality. Post Processing data is accomplished graphically using intuitive controls integrated with mouse and keyboard functions for fast and easy editing. Model Edit features give you access to the properties of the current set of named markers, virtual markers, linkages, and skeletal segments.

EVaRT combines three major functions into a single software package:

1. Calibration of your capture volume
2. Tracking and identifying marker locations in your calibrated 3D space
3. Post processing tools for tracking, editing, and preparing the data for other packages

The advanced calibration procedures calibrate the 3D volume with ease and accuracy.

Options for using the software include:

1. Color video capture-synchronized with the **EVaDV** software—either on your capture computer or on one or more auxiliary computers
2. Synchronized analog channels—capable of collecting 32 and 64 channels of analog data at any frequency between 60 and 5000 Hz
3. Genlock to your studio camera with the Eagle and Hawk cameras
4. Si—Solver for generating constant bone-length skeletons for high quality animation
5. OrthoTrak—clinical gait evaluation module
6. SIMM—Software Interaction Muscle Modeling
7. KinTrak—research module for defining research projects with kinematic and kinetic data and a trial and subject database

System Requirements

Table 1-1. Required Minimum and Recommended Specifications

Required Minimum Specifications	Recommended Specifications
Dual 2.0 GHz CPU (up to 12 cameras)	Dual 2.8 GHz Xeon CPU
512 MB RAM	1.0 GB RAM
Windows 2000™ or **Windows XP™** operating system	**Windows 2000™** or **Windows XP™** operating system
OpenGL video card with 64 MB RAM capable of (1280x1024) resolution	OpenGL video card with 128 MB RAM capable of (1280x1024) resolution
17 inch or larger monitor capable of (1280x1024) resolution	19 inch or larger monitor capable of (1280x1024) resolution
20 GB hard drive (IDE or SCSI)	80 GB hard drive (IDE or SCSI)
1.44 MB or larger floppy disk drive	1.44 MB or larger floppy disk drive
Internal CD-RW drive	Internal CD-RW drive
1-port, 1000 Mbps Network Interface Card (NIC)	1-port, 1000 Mbps Network Interface Card (NIC), quantity of 2
104 key keyboard	104 key keyboard
Three-button mouse. The program requires a middle mouse button for zooming and selecting in several of the graphical panes.	Three-button mouse. The program requires a middle mouse button for zooming and selecting in several of the graphical panes.
	USB 2.0
	IEEE 1394 (standard Firewire)

Hardware

EVaRT will perform best with a dual processor host computer with an OpenGL graphics card. This is used for all types of cameras.

Using Eagle and Hawk Digital Cameras

The Eagle and Hawk digital camera motion capture system includes a set of Eagle and Hawk digital cameras with ring lights, LAN/power cables, and an EagleHub system.

Using Falcon Cameras

If you ar using the Falcon, Cohu, or Pulnix cameras, real-time capture requires a **Midas** computer with a fast CPU, fast memory and upgraded video capture cards. Also, the **Midas** operating system must be upgraded to **Windows NT**™ to allow the large memory space necessary for real-time capture.

Middle Mouse Button

For **EVaRT** operations, the middle button is key for zooming and translating through the 3D and XYZ Graphs display. You will need to verify that the middle mouse button is set to the middle button function.

Software

Two new software components are required:

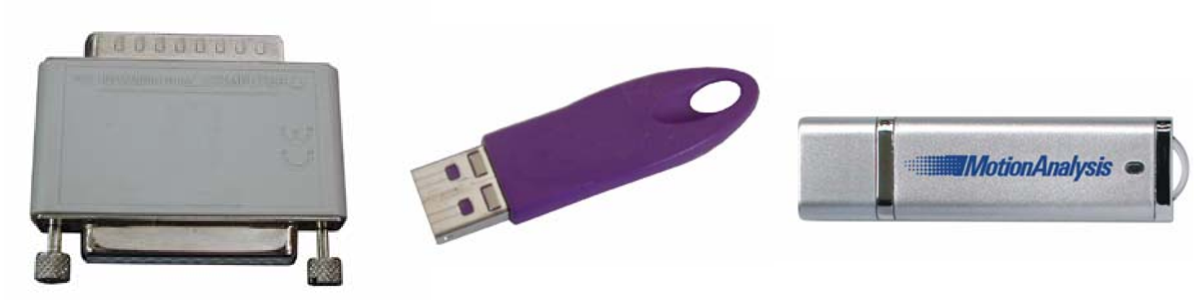
- The **EVaRT** program, running under the host **Windows 2000 Professional**™, or **Windows XP Professional**™ operating system.
- Only if using Falcon cameras—**RT Midas** software with extended capability to handle real-time capture.

Installing the Software and Licenses

To install **EVaRT** for the first time, simply insert the installation CD-ROM into your computer and select the **Setup EVaRT50 No Samples.exe** or **Setup EVaRT50 With Samples.exe** file

Note: To run **EVaRT,** you will need both a license file and a dongle from Motion Analysis Corporation. The license file you receive is keyed to your Motion Analysis dongle number printed on the dongle.

Figure 1-2. Parallel and USB Port Dongles, and Flash Drive



Parallel Port Dongle **USB Port Dongle** **Motion Analysis Flash Drive**

Installation Using the Flash Drive

For new users, **EVaRT** licensing is now provided and setup using Flash Drives. For installation, please follow these steps:

Note: **Please make sure to remove all Dongles from your computer prior to running the EVaRT setup file on the CD. Failure to do so may result in damage to your dongle.**

1. Install the new version of **EVaRT** from the CD-ROM.
2. Install the Sentinel Drivers after the **EVaRT** installation is finished.
3. Insert the Dongle into the USB or Parallel port
4. Insert the Motion Analysis USB Flash drive into a USB port. Double-click on the program: Install.Mac.License and follow the instructions. Press **Y** or **Enter** and the license will be installed onto your hard drive, in the **C:\Program Files\Motion Analysis directory**.
5. On the Task bar, left-click the Green arrow icon and select **Stop USB mass Storage Device**.
6. Unplug the USB Flash Drive and store it in a safe place.

If you need any further information, please consult the **readme.txt** file located on the Motion Analysis USB Flash Drive.

If You Only Have EVaRT Installed

If you have **EVaRT** software already installed, you will need to add a new line to your Motion Analysis license file (provided by Motion Analysis Customer Support).

1. Launch **Notepad**, **Wordpad**, or your favorite ACSII text editor.
2. Navigate to **C:\Program Files\Motion Analysis**.
3. Open the **mac_lic.dat** file.
4. Add the new line beginning with `[EVaRT v50]` from your new license to the bottom of your current license as shown below.

Figure 1-3. Sample Motion Analysis License File

```
Motion Analysis License File
Customer: MAC Customer
Platform: NT
SystemID: 19c
Created: 9/15/2005 1:42:26 PM
Sales Order#: 05-xxx
Entered By: Support
[EVa RealTime v5.0]  aed50167    873b2d56
[Analog Input]       b9806c31    d1567841
[OrthoTrak]          b2df5e69    8964274a
[Animation Plugins]  b1a50160    805b5c49
[Director/Sequencer] e1a04e65    85745819
[RT2 Animation Plugins] e3f05340    a069081b
[Analog Input]       b9806c31    d1567841
[Calcium 4]          e7ed5923    c363151f
[Skeleton Builder 4] a3f44279    99780c5b
[Reference Video 3.0] eb92592f    cf636a13
[Talon Streaming 4]  ecb36136    d65b4b14
[Talon Viewer 4]     86fb0714    f43d037e
[BioFeedTrak]        ac943872    92026c54
[Motion Composer]    c7f00e25    c534083f
This license has no expiration.
```

If You Install a Dongle

Computers with a new dongle installed need to load the dongle drivers so that the application will detect the dongle.

You can choose to install the dongle drivers when initially installing the **EVaRT** software or you can run the drivers independently by running the program in the **Sentinel Drivers** directory under the **EVaRT** folder.

Operating Systems in Different Languages

If the operating system you are using on your tracking or post processing computer is a non-English version, some characters may not be recognized and you may experience installation problems.

If you are experiencing this, you will need to go into the computer and set it to allow for English Unicode characters. In **Windows XP,** you can do this by going to **Start > Control Panel > Regional and Language Settings**. This brings up a window that has 3 tabs, and the second one is the Language Tab. Under the Text Services and Input Languages tab, you need to click on the **Details** button and add the setting for English (United States). This will add the necessary text characters to the computer.

Alternatively, you can install an English language OS on your computer.

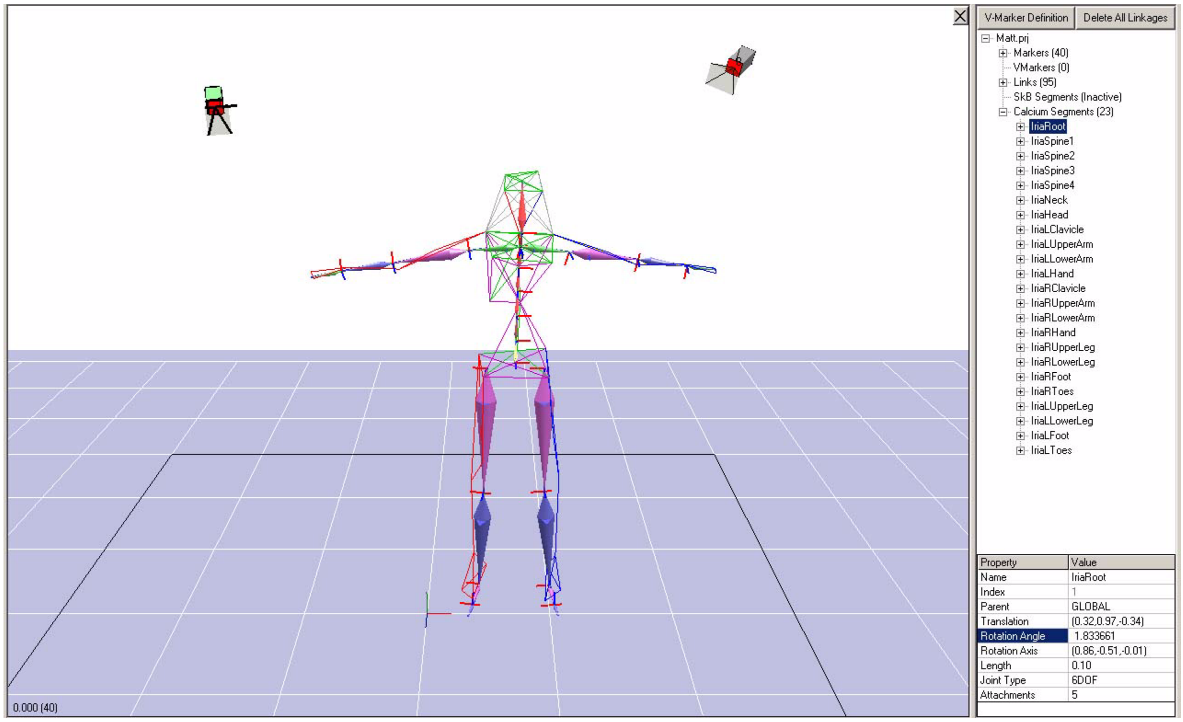
Software Packages within EVaRT

The following are software products offered by Motion Analysis that are integrated within the **EVaRT** user interface. These files will require a license file and an OCX file to use.

Calcium

Calcium is the graphical user interface to the Solver engine. Solver is the powerful numerical tool for calculating skeleton motion from marker data. The Calcium interface in **EVaRT** is what allows you to correlate the positions of a marker pose to the initial pose of a skeleton. The skeleton is usually created in an outside animation package, such as Maya, 3D Studio Max or Kaydara and then exported to an HTR file by a Motion Analysis file IO plugin for that package.

Figure 1-4. Calcium Interface in EVaRT


V-Marker Definition
Delete All Linkages
Matt.prj
Markers (40)
VMarkers (0)
Links (95)
SkB Segments (Inactive)
Calcium Segments (23)
IriaRoot
IriaSpine1
IriaSpine2
IriaSpine3
IriaSpine4
IriaNeck
IriaHead
IriaLClavicle
IriaLUpperArm
IriaLLowerArm
IriaLHand
IriaRClavicle
IriaRUpperArm
IriaRLowerArm
IriaRHand
IriaRUpperLeg
IriaRLowerLeg
IriaRFoot
IriaRToes
IriaLUpperLeg
IriaLLowerLeg
IriaLFoot
IriaLToes
0.000 (40)

Property	Value
Name	IriaRoot
Index	1
Parent	GLOBAL
Translation	(0.32,0.97,-0.34)
Rotation Angle	1.833661
Rotation Axis	(0.86,-0.51,-0.01)
Length	0.10
Joint Type	6DOF
Attachments	5

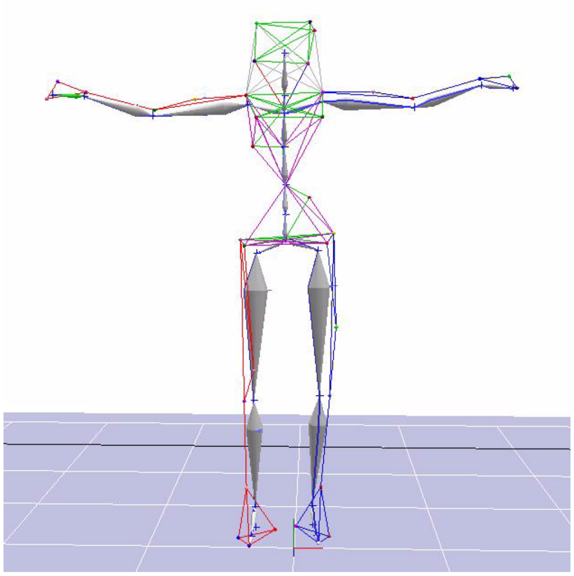
Solver Interface (Si) is the same software as Calcium, only that it’s interface is separate from **EVaRT**.

Skeleton Builder (SkB)

A skeleton, in animation parlance, is a hierarchically connected set of bones with translation and rotation data. Each bone has a parent and potentially any number of children. One special bone has no parent and is usually referred to as the "root" of the skeleton. Skeleton Builder, as the name implies, is a tool that allows you to construct a skeleton by creating bones and arranging them in a hierarchy. Each bone is defined by the motion of three markers used to construct its rotation data. The Skeleton Builder interface is incorporated with the **EVaRT** interface.

Skeleton Builder bone definitions are stored in the **EVaRT** project file. Any time you wish to save the definitions you have created simply save out a project file. Various project files are stored in the sample directory which contain the example skeleton at various stages of construction.

Figure 1-5. SkB Skeleton



Motion Composer

Motion Composer is a suite of tools for collating, integrating, and presenting interactive motion capture data. Motion Composer is a collection of authoring tools, data structures, and visualization panes. These are integrated into **EVaRT** to help achieve a seamless workflow for the user to package and present a motion capture session. Some of the key features to be found in Motion Composer are described in the following sections.

Integrated Authoring

Motion Composer is designed as a plugin into **EVaRT**. This integration allows new and existing users a seamless pathway from data collection to collation and presentation with a minimal learning curve. For current users, this integration leverages their existing knowledge of **EVaRT**. Presentation output can be as simple as redirecting an **EVaRT** project to presentation format.

Interactive Player

Motion Composer ships with Motion View, a freely distributable interactive player that enables customers to distribute their presentations quickly and easily. When it's time to send research data to a colleague or take it on the road, authors can simply pack-and-go, turning their presentation into a single packaged ZIP file for quick burning to CD or emailing to a friend. With the interactive player inside, presentations are ready for launch on any Windows 2000/XP operating system.

Rich Media Support

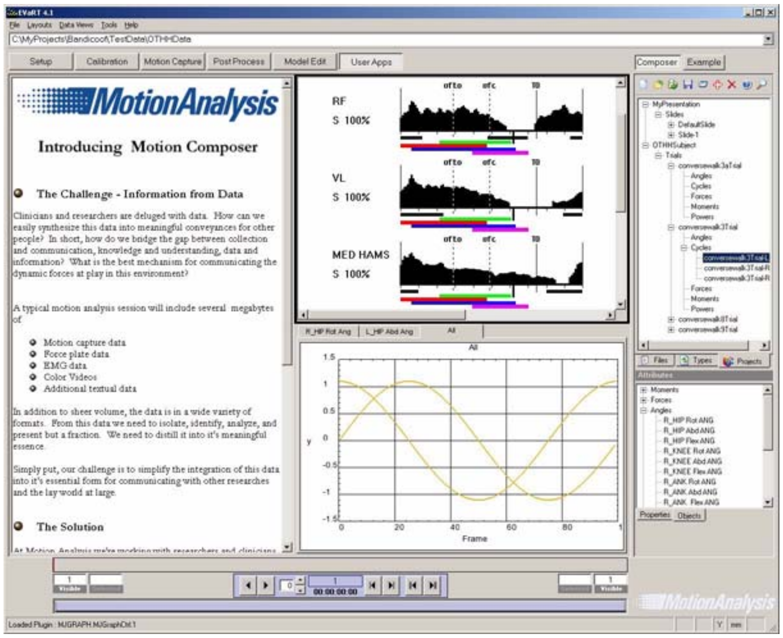
Motion Composer supports the import of a wide variety of information formats, allowing users to import not just motion capture data but data from third party applications, such as EMG analysis graphs, additional color video footage, and still images. It also allows users to import user generated data such as clinical notes, Microsoft Word documents, and embedded HTML link. Below is list of the file formats Motion Composer supports:

- Text (TXT, RTF, HTML, XLS)
- Color Video (MPG, AVI)
- Images (JPG, GIF, BMP)
- Motion Analysis OrthoTrak XLS files (cycles, moment, forces, angles, powers)
- Project files (PRJ)
- Tracks (TRC/TRB)
- Analog data (ANB)
- User defined data types/views

Presentation Tools

The Motion Composer authoring interface provides a simple hierarchical interface to easily manage a user’s disparate files, offering views of referenced files, data structures (e.g. moments, powers, forces), or relationship structures (e.g. Subject/Condition/Trial/Cycle). The Motion Composer authoring interface also makes it simple to create presentations. As data is added, the author simply creates a view of the data they wish to convey and stores this view as a slide. Presentation viewing becomes as simple as a slideshow.

Figure 1-6. Motion Composer Interface


EVaRT 4.1
File Layouts Data Views Tools Help
C:\MyProjects\Bandicoot\TestData\OTHHData
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
MotionAnalysis
RF
S 100%
VL
MED HAMS
ofto
ofc
TO
R_HIP Rot Ang
L_HIP Abd Ang
All
Frame
y
Composer
Example
Files
Types
Projects
Attributes
Properties
Objects
Loaded Plugin : MJGRAPH.MJGraphCtrl.1

Introducing Motion Composer

The Challenge - Information from Data

Clinicians and researchers are deluged with data. How can we easily synthesize this data into meaningful conveyances for other people? In short, how do we bridge the gap between collection and communication, knowledge and understanding, data and information? What is the best mechanism for communicating the dynamic forces at play in this environment?

A typical motion analysis session will include several megabytes of

- Motion capture data
- Force plate data
- EMG data
- Color Videos
- Additional textual data

In addition to sheer volume, the data is in a wide variety of formats. From this data we need to isolate, identify, analyze, and present but a fraction. We need to distill it into it's meaningful essence.

Simply put, our challenge is to simplify the integration of this data into it's essential form for communicating with other researches and the lay world at large.

The Solution

BioFeedTrak

BioFeedTrak is a general condition, evaluation, and response program for designing and implementing biofeedback programs that can enable clinicians and patients to receive instantaneous audio feedback to kinematic and kinetic variables. **BioFeedTrak** is able to give real-time feedback in the form of sounds based on kinematic and kinetic variables that fall within certain bounds during the pre-defined performance of any type of physical task.

Kinematic variables include position, velocity and acceleration of individual markers placed on key anatomical points of interest. Included angle between two segments (defined by three or four markers) as well as the angle of inclination of a segment (defined by two markers), with respect to a global reference coordinate system, can be used to provide feedback. Kinetic data include the following:

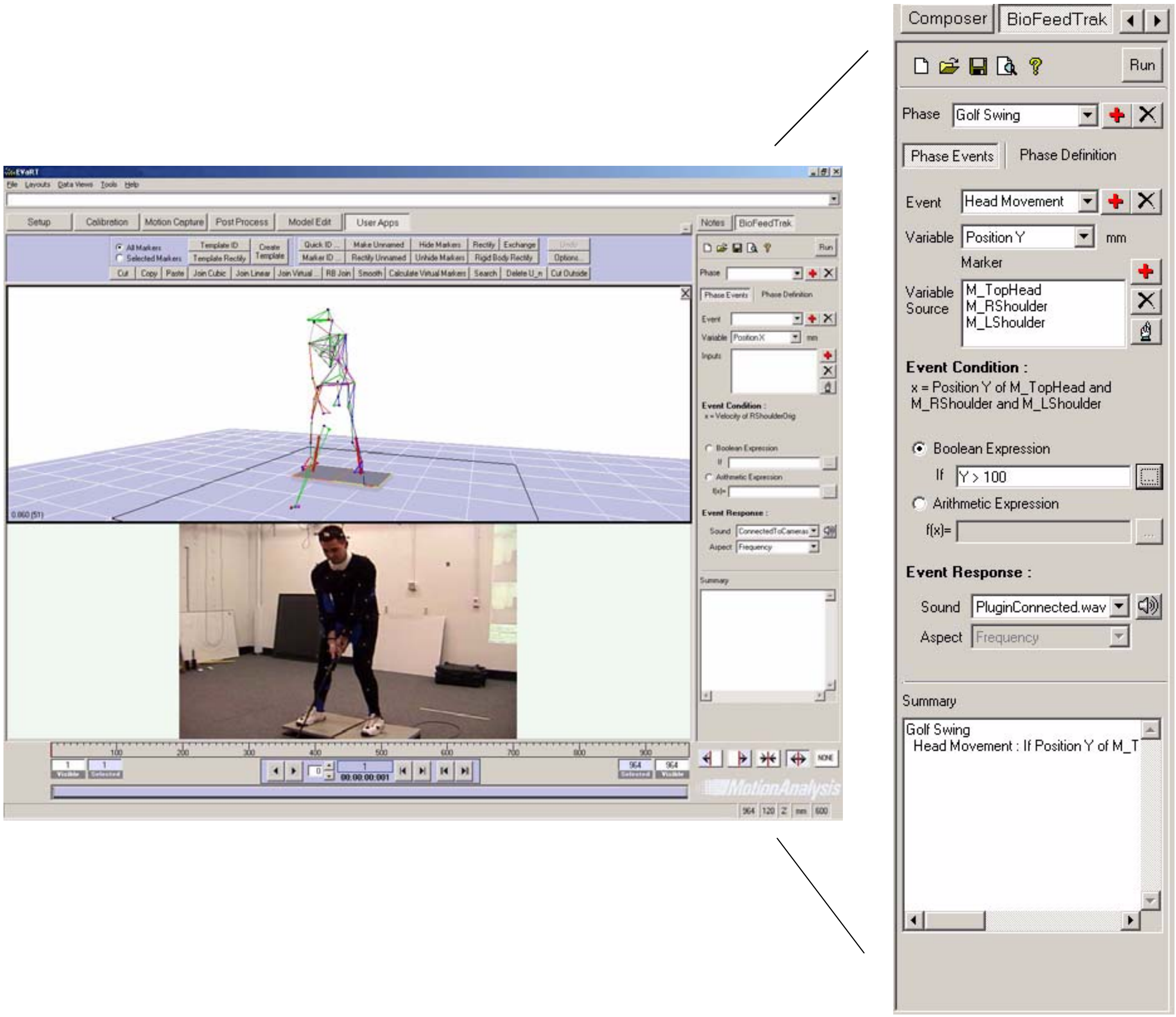
- horizontal and vertical forces
- moment about the vertical axis
- the coordinates of the center of pressure with respect to the global reference coordinate system

The program works in conjunction with the Motion Analysis Eagle/Hawk Digital System or the Falcon Analog System. For a typical application procedure, the user will do the following:

1. Choose and set the variables to be monitored
2. Determine the starting and ending parameters for each variable to be assessed
3. Choose the volume and frequency of the audio feedback
4. Start the Real-Time system

With this, the patient and clinician are able to work side by side to retrain areas of the body that need further optimization.

Figure 1-7. BioFeedTrak User Interface with EVaRT


Composer
BioFeedTrak
Run
Phase Events
Phase Definition
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
MotionAnalysis

Phase: Golf Swing

Event: Head Movement

Variable: Position Y mm

Variable Source (Marker): M_TopHead, M_RShoulder, M_LShoulder

Event Condition : x = Position Y of M_TopHead and M_RShoulder and M_LShoulder

● Boolean Expression If Y > 100

○ Arithmetic Expression f(x)=

Event Response : Sound: PluginConnected.wav Aspect: Frequency

Summary: Golf Swing Head Movement : If Position Y of M_T

BioFeedTrak allows users to define a set of variable-condition-response relationships with motion capture data. Each variable-condition-response is referred to as an event. For example, "If the elbow angle of the subject is less than 45 degrees play a tone" where "elbow angle" is the variable, "less than 45 degrees" is the condition, "play a tone" is the response.

Digital Video Option (EVaDV Software)

The color Digital Video option allows you to record a time-matched Reference Video along with your motion capture trial on a separate computer. With this option, you will record a time-matched color video AVI file with the same trial name in your motion capture folder. A separate computer is used in order to not burden your **EVaRT** Host computer, which is an issue if your computer is too slow for the number of markers being tracked. For single person captures, you may connect the DV Camera directly to the **EVaRT** Host computer. In this case, the **EVaDV** software is not needed. It is built into the **EVaRT** software. You can run **EVaDV** on one or more computers and then capture multiple AVI files (multiple views). They will all have the same AVI file name. You may experience a small delay in frames from the **EVaRT** software and the **EVaDV** software when capturing. The Color Video display has a pop-up menu with one item, Adjust Frame Offset. This allows for time-matching data streams.

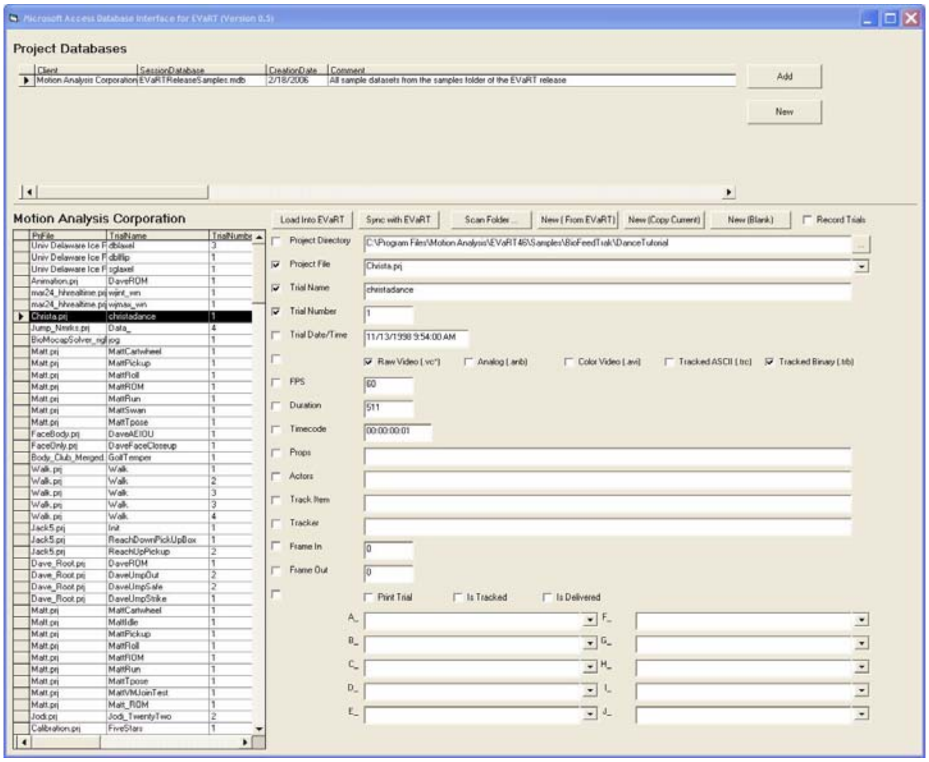
QuickDB

QuickDB is an integrated database tool for EVaRT that allows the user to easily track all EVaRT project information. Microsoft Access databases are used to tabulate information about your projects (you don't have to own a copy of Access to take advantage of this tool). A master database keeps a list of all the individual projects you make. Each individual project (called a "session list") keeps track of all the data associated with a specific project directory (project files, VC files, tracks files, etc...). It is fast and easy to create a session list of any data you already have, QuickDB will scan your project directory for the data you have already collected and will create the session database for you.

QuickDB is all of the following:

- Is very handy for keeping track of all your projects, you can scan for and then load project data with ease.
- Will record your trials as you collect data.
- Contains tracking information about a trial's Post Process status.
- Allow's multiple user access to shared session databases.
- Makes it easy to share databases with other users.
- Allows the creation of capture lists ahead of time so that capture names can be loaded from QuickDB while recording a session.
- Is an SQL database that can be used to generate reports on project status.

Figure 1-8. QuickDB Interface



Client	SessionDatabase	CreationDate	Comment
Motion Analysis Corporation	EVaRTReleaseSamples.mdb	2/18/2006	All sample datasets from the samples folder of the EVaRT release

PrjFile	TrialName	TrialNumbe
Univ Delaware Ice F	dblaxel	3
Univ Delaware Ice F	dblflip	1
Univ Delaware Ice F	sglaxel	1
Animation.prj	DaveROM	1
mar24_hhrealtime.prj	wjint_win	1
mar24_hhrealtime.prj	wjmax_win	1
Christa.prj	christadance	1
Jump_Nmrks.prj	Data_	4
BioMocapSolver_ngl	jog	1
Matt.prj	MattCartwheel	1
Matt.prj	MattPickup	1
Matt.prj	MattRoll	1
Matt.prj	MattROM	1
Matt.prj	MattRun	1
Matt.prj	MattSwan	1
Matt.prj	MattTpose	1
FaceBody.prj	DaveAEIOU	1
FaceOnly.prj	DaveFaceCloseup	1
Body_Club_Merged	GolfTemper	1
Walk.prj	Walk	1
Walk.prj	Walk	2
Walk.prj	Walk	3
Walk.prj	Walk	3
Walk.prj	Walk	4
Jack5.prj	Init	1
Jack5.prj	ReachDownPickUpBox	1
Jack5.prj	ReachUpPickup	2
Dave_Root.prj	DaveROM	1
Dave_Root.prj	DaveUmpOut	2
Dave_Root.prj	DaveUmpSafe	2
Dave_Root.prj	DaveUmpStrike	1
Matt.prj	MattCartwheel	1
Matt.prj	MattIdle	1
Matt.prj	MattPickup	1
Matt.prj	MattRoll	1
Matt.prj	MattROM	1
Matt.prj	MattRun	1
Matt.prj	MattTpose	1
Matt.prj	MattVMJoinTest	1
Matt.prj	Matt_ROM	1
Jodi.prj	Jodi_TwentyTwo	2
Calibration.prj	FiveStars	1

☐ Record Trials

☐ Project Directory: C:\Program Files\Motion Analysis\EVaRT46\Samples\BioFeedTrak\DanceTutorial
☑ Project File: Christa.prj
☑ Trial Name: christadance
☑ Trial Number: 1
☐ Trial Date/Time: 11/13/1998 9:54:00 AM
☐ ☑ Raw Video (.vc*) ☐ Analog (.anb) ☐ Color Video (.avi) ☐ Tracked ASCII (.trc) ☑ Tracked Binary (.trb)
☐ FPS: 60
☐ Duration: 511
☐ Timecode: 00:00:00:01
☐ Props:
☐ Actors:
☐ Track Item:
☐ Tracker:
☐ Frame In: 0
☐ Frame Out: 0
☐ ☐ Print Trial ☐ Is Tracked ☐ Is Delivered
A_
B_
C_
D_
E_
F_
G_
H_
I_
J_

Software Packages Used with EVaRT

The following are software products offered by Motion Analysis that are used in conjunction with **EVaRT**. These files will require a license file and a separate installation package.

Animation Plugins

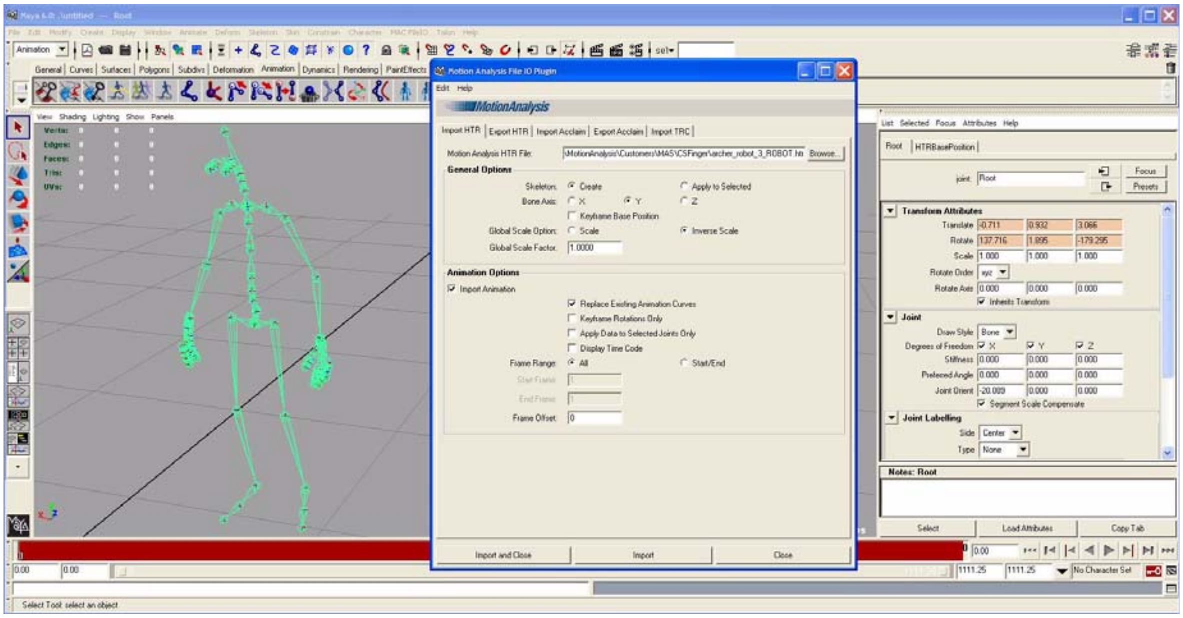
The MAC Animation Plugins, also known as the File IO plugins, are used to read and write Motion Analysis motion capture files (TRC or TRB). These plugins are available in all the major animation software packages including:

- Maya
- 3DS MAX
- Softimage XSI
- Lightwave
- Alias Motion Builder.

The Motion Analysis HTR file format is used for skeleton motion capture data. The Animation Plugins can take an existing character skeleton and export it to an HTR file (usually for use in Calcium) and it can take an HTR file created by Calcium and apply it to the character in the animation software.

The Motion Analysis TRC file format is used for tracked (markers) motion capture data. This data is generally only imported into the animation software. It is used for bringing in full body marker data, face data and prop data.

Figure 1-9. Animation Plugins Interface



Motion Analysis File IO Plugin
Edit
Help
MotionAnalysis
Import HTR
Export HTR
Import Acclaim
Export Acclaim
Import TRC
Browse...
General Options
Animation Options
Import and Close
Import
Close
List
Selected
Focus
Attributes
Help
Root
HTRBasePosition
Focus
Presets
Transform Attributes
Joint
Joint Labelling
Notes: Root
Select
Load Attributes
Copy Tab
No Character Set

Motion Analysis HTR File: \MotionAnalysis\Customers\MAS\CSFinger\archer_robot_3_ROBOT.htr

Skeleton: ● Create ○ Apply to Selected
Bone Axis: ○ X ● Y ○ Z
☐ Keyframe Base Position
Global Scale Option: ○ Scale ● Inverse Scale
Global Scale Factor: 1.0000

☑ Import Animation
☑ Replace Existing Animation Curves
☐ Keyframe Rotations Only
☐ Apply Data to Selected Joints Only
☐ Display Time Code
Frame Range: ● All ○ Start/End
Start Frame: 1
End Frame: 1
Frame Offset: 0

joint: Root

Translate	-0.711	0.932	3.066
Rotate	137.716	1.895	-179.295
Scale	1.000	1.000	1.000
Rotate Order	xyz		
Rotate Axis	0.000	0.000	0.000

☑ Inherits Transform

Draw Style	Bone		
Degrees of Freedom	☑ X	☑ Y	☑ Z
Stiffness	0.000	0.000	0.000
Preferred Angle	0.000	0.000	0.000
Joint Orient	-20.009	0.000	0.000

☑ Segment Scale Compensate

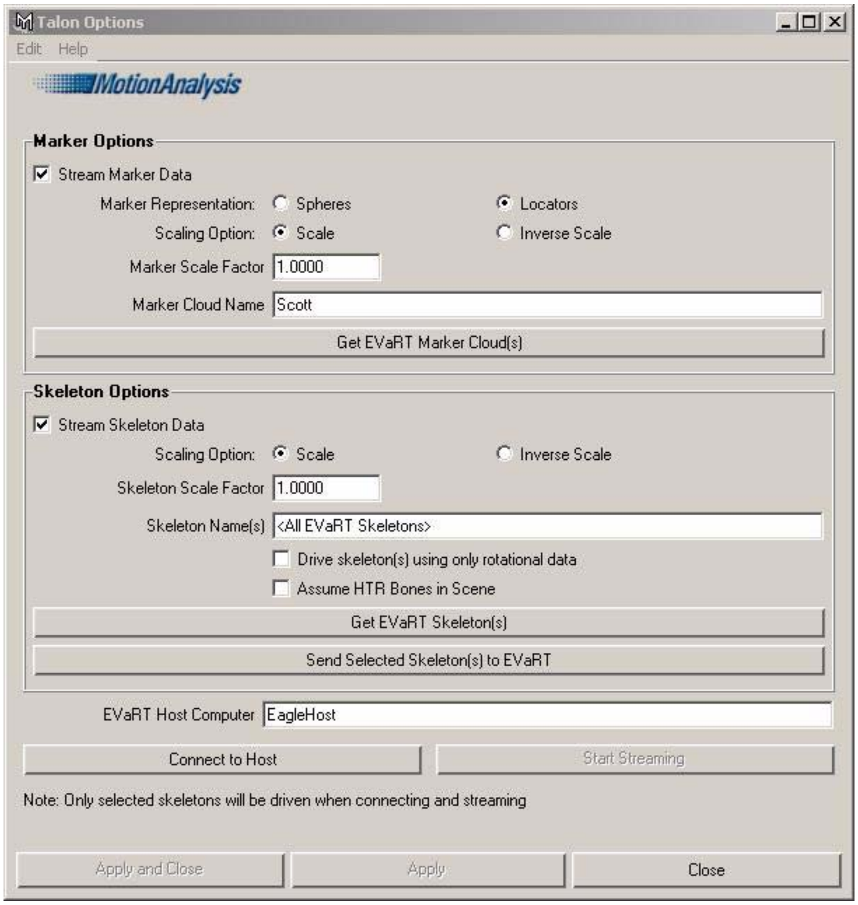
Side: Center
Type: None

Talon Plugins

The MAC Talon Plugins, also known as the streaming plugins, are used to stream data from a live, realtime connection to **EVaRT** into an animation software package. Both skeleton and marker data can be streamed. This function is available for Maya, Mocap, and 3DSMAX. Additional animation packages are currently under development.

This same interface is used by outside developers to stream motion capture data into their own custom environments. This programming interface is called the SDK and is available upon request.

Figure 1-10. Talon Plugins Maya Interface


Talon Options
Edit
Help
MotionAnalysis
Marker Options
Get EVaRT Marker Cloud(s)
Skeleton Options
Get EVaRT Skeleton(s)
Send Selected Skeleton(s) to EVaRT
Connect to Host
Start Streaming
Apply and Close
Apply
Close

☑ Stream Marker Data

Marker Representation: ○ Spheres ● Locators

Scaling Option: ● Scale ○ Inverse Scale

Marker Scale Factor 1.0000

Marker Cloud Name Scott

☑ Stream Skeleton Data

Scaling Option: ● Scale ○ Inverse Scale

Skeleton Scale Factor 1.0000

Skeleton Name(s) <All EVaRT Skeletons>

☐ Drive skeleton(s) using only rotational data

☐ Assume HTR Bones in Scene

EVaRT Host Computer EagleHost

Note: Only selected skeletons will be driven when connecting and streaming

Talon Viewer

Note: Talon Viewer is no longer supported by Motion Analysis Corp.

OrthoTrak

OrthoTrak is a completely integrated full-body gait analysis package designed for use in clinical and research studies of human locomotion. The system provides state of the art software designed to be used by clinicians in orthopaedics, neurology, and physical therapy, or for any person interested in assessing locomotor abilities of humans.

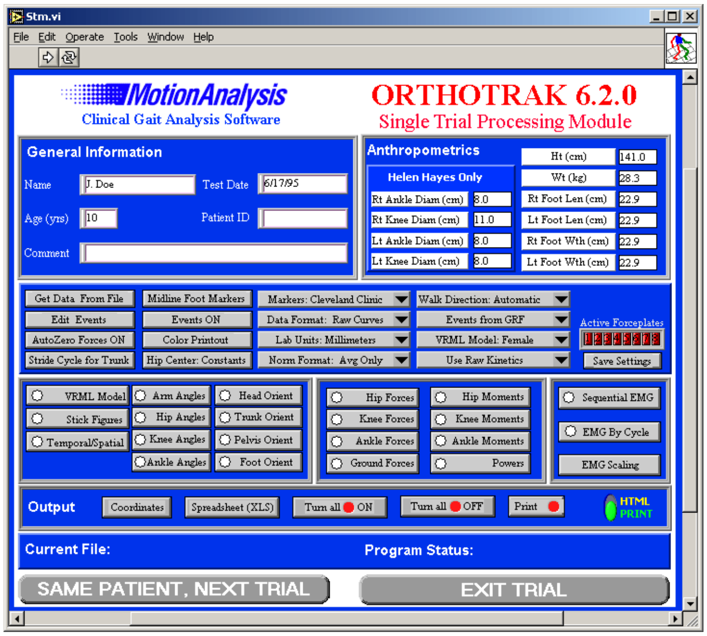
The system provides:

- quantification of 3D body, segmental, and joint motions
- analysis of the forces occurring in locomotion
- records of neuromuscular function through electromyography

Intended Use

OrthoTrak is designed primarily for analyzing a walking motion over level ground but can also be used for walking on treadmills, up and down stairs, or other activities. Gait data are presented in graphs which describe the kinematic (angles), kinetics (moments), and muscle activity (EMG). Data can be exported as industry-standard XLS data sets which can easily be imported into **Microsoft Excel**™ or other graphics and analysis packages.

Figure 1-11. OrthoTrak Interface


Stm.vi
File Edit Operate Tools Window Help
MotionAnalysis
Clinical Gait Analysis Software
ORTHOTRAK 6.2.0
Single Trial Processing Module
General Information
Anthropometrics
Helen Hayes Only
Get Data From File
Midline Foot Markers
Edit Events
Events ON
AutoZero Forces ON
Color Printout
Stride Cycle for Trunk
Hip Center: Constants
Active Forceplates
1 2 3 4 5 6 7 8
Save Settings
○ VRML Model
○ Stick Figures
○ Temporal/Spatial
○ Arm Angles
○ Hip Angles
○ Knee Angles
○ Ankle Angles
○ Head Orient
○ Trunk Orient
○ Pelvis Orient
○ Foot Orient
○ Hip Forces
○ Knee Forces
○ Ankle Forces
○ Ground Forces
○ Hip Moments
○ Knee Moments
○ Ankle Moments
○ Powers
○ Sequential EMG
○ EMG By Cycle
EMG Scaling
Output
Coordinates
Spreadsheet (XLS)
Turn all ● ON
Turn all ● OFF
Print ●
HTML PRINT
Current File:
Program Status:
SAME PATIENT, NEXT TRIAL
EXIT TRIAL

Name: J. Doe
Test Date: 6/17/95
Age (yrs): 10
Patient ID:
Comment:

Ht (cm)	141.0
Wt (kg)	28.3
Rt Ankle Diam (cm)	8.0
Rt Knee Diam (cm)	11.0
Lt Ankle Diam (cm)	8.0
Lt Knee Diam (cm)	8.0
Rt Foot Len (cm)	22.9
Lt Foot Len (cm)	22.9
Rt Foot Wth (cm)	22.9
Lt Foot Wth (cm)	22.9

Markers: Cleveland Clinic
Data Format: Raw Curves
Lab Units: Millimeters
Norm Format: Avg Only
Walk Direction: Automatic
Events from GRF
VRML Model: Female
Use Raw Kinetics

KinTrak

KinTrak is a movement analysis system that enables you to import and analyze three-dimensional kinetic (force), kinematic (video), and channel (e.g. EMG) data from a biomechanical perspective.

Existing biomechanical software tends to be geared toward solving specific problems, and is not usually adaptable in new situations. This has resulted in programs that are too restrictive in data control, collection and analysis. **KinTrak** is designed to overcome these problems by allowing users to tailor the program to suit their specifications and the requirements of the project or study they are undertaking.

KinTrak is intended to be used by researchers and clinicians in the fields of biomechanics and human movement. In addition, coaches and assistants of sports teams may find it useful for their purposes. Possible uses of **KinTrak** include studies for the purpose of prevention of athletic injuries, analysis of gait characteristics, assessment of athletic footwear, and development of prosthetic appliances.

Director/Sequencer

Director/Sequencer allows the animator to perform *non-linear* editing of motion data on screen. Just as a sound engineer uses a multi-track digital workstation to edit and combine many tracks of sound, the **Director/Sequencer** gives the animator the ability to do the same with motion captured data.

The animator starts with a collection of files containing motion data for an object or a hierarchical skeleton. Each file that is loaded is displayed as a move in **Director/Sequencer**. Each move is represented as a time line in an **Editor** area and a 3D character in a **Viewer** area.

By simply pointing and clicking with the mouse, the animator can slide a move backward or forward in time in the Editor area. In the Viewer area, both the position and orientation of each figure can be modified. Two moves can be joined together so that there exists a user defined region where one is blended into the other. Finally, any part of a figure's motion can be hand edited to give the animator complete control of the finished animation.

Each move is stored as a Hierarchal Translations and Rotations (***.htr** or HTR) file which contains motion data for a hierarchical skeleton. After all moves have been choreographed, they are once again saved as HTR files which can then be used as input to one of the popular animation software packages to generate the final animated scene.

SIMM

SIMM (Software for Interactive Musculoskeletal Modeling) is a software system that enables you to create and analyze graphics-based models of the musculoskeletal system. In **SIMM**, a musculoskeletal model consists of a set of bones that are connected by joints. Muscle-tendon actuators and ligaments span the joints. The muscles and ligaments develop force, thus generating moments about the joints.

SIMM allows you to analyze and test a musculoskeletal model by calculating the moment arms and lengths of the muscles and ligaments. Given muscle activations, the forces and joint moments (muscle force multiplied by moment arm) that each muscle generates can be computed for any body position. By manipulating a model on the computer graphics system, you can quickly explore the effects of changing musculoskeletal geometry and other model parameters.

Since the software can be used to study many different musculoskeletal structures, it can enhance the productivity of investigators working on diverse problems in biomechanics. **SIMM** provides a framework that organizes the parameters of a model and allows people to work together on a modeling project. The moving, three-dimensional images of anatomical structures that you can create are extremely valuable when developing a model and when communicating the results of an analysis.

Applications

SIMM has a wide variety of applications. A few examples include the following.

- Biomechanics researchers are using **SIMM** to create models of the human elbow, wrist, jaw, and other anatomical structures. These models can be altered according to particular surgical procedures to study how the surgical alterations affect muscle function. SIMM can also be used to analyze and display the mechanics of injuries.
- Neuroscientists are using **SIMM** to study how the central nervous system controls movement. For example, muscle activation patterns determined from electromyographic recordings can be used to estimate muscle forces and joint moments generated during a task. The computed joint moments can then be compared to experimentally recorded moments.
- Medical students and residents can use models created with **SIMM** to study musculoskeletal anatomy and function. In addition to visualizing anatomical structures, students gain an appreciation for the interplay of muscle architecture and joint geometry.
- Kinesiologists who record and analyze the motion of persons with movement disabilities can use **SIMM** to create three-dimensional animations of a person's movement. Movements, such as walking, can be quantitatively compared to normal movement to gain insight into the causes of movement deformities. Motion can also be analyzed in the context of optimizing athletic performance.
- Human factors engineers who need to account for muscle strengths when designing products or work stations can use **SIMM** to study how posture effects muscle strength. Limits on joint ranges of motion can also be taken into account.
- Biologists interested in animal movement can create models to quantify limb function. Investigating movement strategies in other species can provide insights needed to design machines that move.
- Computer scientists who develop models of the human body for virtual environments can use **SIMM** to create the models and compare them with biomechanical data for verification.
- Animators can use **SIMM** to develop realistic representations of human and animal movements. World objects can be added to provide a context for the animation.

For More Information

Please contact Motion Analysis Customer Support with any questions, problems, or feedback about the Motion Analysis **EVaRT** software. We can be reached at:

Motion Analysis Corporation
3617 Westwind Blvd.
Santa Rosa, CA, USA 95403

Phone: 707-579-6500
Fax: 707-526-0629

http://www.motionanalysis.com

For technical support and licensing information, please contact:

support@motionanalysis.com

For information about sales, please contact:

info@motionanalysis.com

Chapter 2

Quick-Start Tutorial for Movement Analysis Applications

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Overview	2-1
Starting EVaRT	2-1
Project Initialization	2-2
System Calibration	2-4
Setup Analog	2-8
Marker Placement	2-9
Data Capture	2-11

Overview

This chapter provides a quick reference to begin using your motion capture system for Movement Analysis applications, and is intended for the more advanced motion capture system user. For Animation Production applications, refer to Chapter 3, Quick-Start Tutorial for Animation Production Applications.

Note: This Quick-start Guide uses a Helen Hayes marker set and starts with a project file that is located in the **C:\Program Files\Motion Analysis\EVaRT 5.0\Samples\Helen Hayes in Otago** folder. The basic methodology outlined here can be generalized to other marker sets. Please be aware, that this data set is more complex since it utilizes two different marker sets (Static and Dynamic), and captures three different sets of data (Static, Dynamic Template, and Dynamic movements).

Starting EVaRT

1. Turn on the Host computer and login.
2. Turn on EagleHub(s) or Midas computer and turn on the cameras (analog system only).
3. Turn on the Forceplate and EMG Amplifiers, if applicable. Make sure to zero the force plate(s) (see the manufacturer manual for more information).

4. Launch the **EVaRT** software by double-clicking the icon located on your computer's desktop.

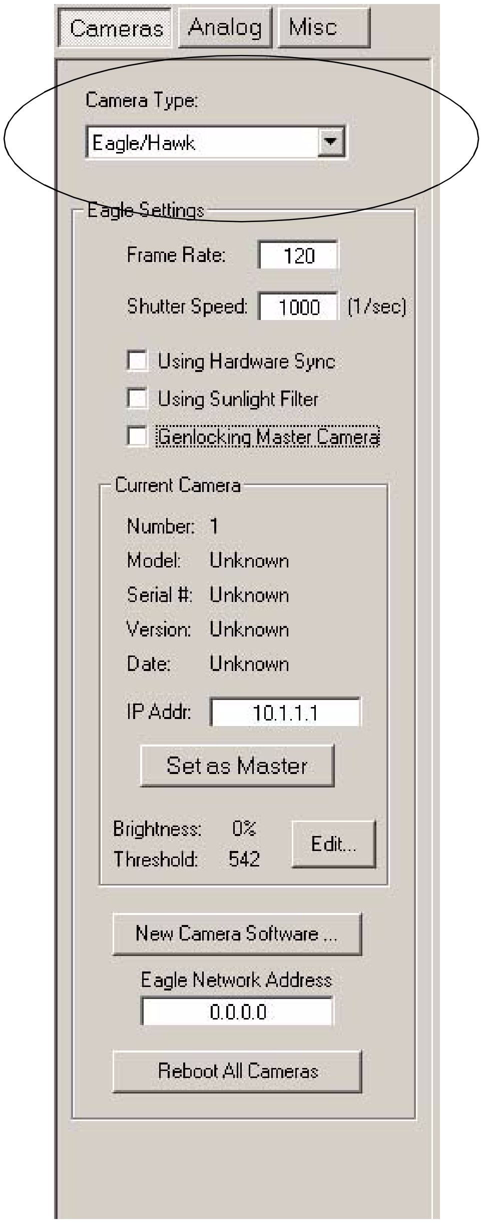
Project Initialization

1. Load a previous project (**File > Load Project**) that has a Helen Hayes static marker set (e.g. **Static.prj**).
   - Project files contain information about calibration, thresholds, masks, tracking parameters, marker sets, and templates.
   - By loading a previous project that contains all of this information, you will not have to re-enter it all each time you start a new capture session. You will only need to update the calibration.
2. Immediately save the project file in a new folder (**File > Save Project As...**).
   - Create a new folder for the subject and save your project there. This directory now becomes the default **EVaRT** directory.

Note: Make sure that you do not write over previous projects. Separate projects are needed in order to run trials for that particular day. If calibration VC files are written over, then recreating the calibration parameters in Post Process mode will not be possible.

3. In the **Setup > Cameras** sub-panel, choose the Camera Type.

Figure 2-1. Setup > Cameras > Camera Type


Cameras
Analog
Misc
Eagle Settings
Current Camera
Set as Master
Edit...
New Camera Software ...
Reboot All Cameras

Camera Type: Eagle/Hawk

Frame Rate: 120

Shutter Speed: 1000 (1/sec)

☐ Using Hardware Sync

☐ Using Sunlight Filter

☐ Genlocking Master Camera

Number: 1
Model: Unknown
Serial #: Unknown
Version: Unknown
Date: Unknown

IP Addr: 10.1.1.1

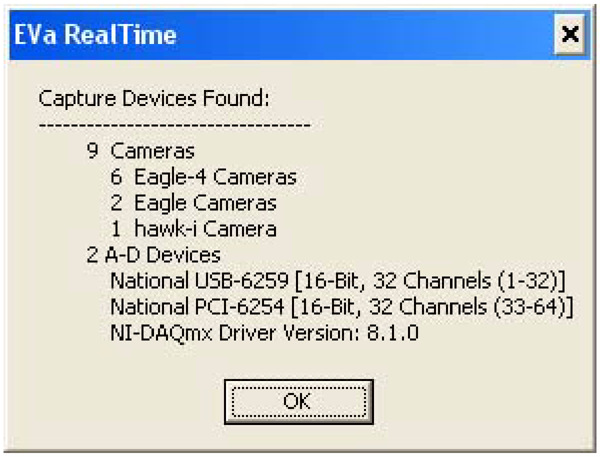
Brightness: 0%
Threshold: 542

Eagle Network Address
0.0.0.0

- Under the Eagle/Hawk settings, choose **Frame Rate** and set the default shutter speed and brightness.
- Under the Falcon Camera settings, the user selects the camera and the camera speed simultaneously. Leave the default Midas settings.

4. Press **Connect to Cameras.**
    - The first time you do this step, a message indicating that "X number of cameras were found, existing project has 2. Do you want to modify project?" may appear. See Figure 2-2. Press the **OK** button.

Figure 2-2. Connect to Cameras Status Pop-Up (Example)



```
Capture Devices Found:
--------------------------------
    9  Cameras
       6  Eagle-4 Cameras
       2  Eagle Cameras
       1  hawk-i Camera
    2 A-D Devices
       National USB-6259 [16-Bit, 32 Channels (1-32)]
       National PCI-6254 [16-Bit, 32 Channels (33-64)]
       NI-DAQmx Driver Version: 8.1.0
```

System Calibration

Note: System calibration should be done at a camera speed of 60 Hz.

Start the Calibration Process Using the (4-Point) L-Frame Calibration Square

1. Place the calibration square device or four markers (L-shaped) on the floor or on the forceplate.
    - The Calibration Square markers are described under **Tools > Calibration Settings**. These markers have been placed in a particular orientation and precise distances apart in order to tell the software the origin and coordinate (XYZ) system of the lab/room.
2. Under the **Calibration > Calibrate** sub-panel, activate the Preview Calibration check-box.
3. Press the **Run** button.
    - All the number buttons on the bottom of the **EVaRT** interface should turn yellow if all of them can see the L-frame.
4. Select **Layouts > 2 Panes: Top/Bottom**.
    - We want the 3-D Display window and 2-D Display window showing. These can be set by left-clicking in the window to make it active and then select **Data Views > 3D Display** or **2D Display**.
5. Check the 2-D views on all the cameras.
    - There should only be four markers in each camera view. If there are less, you may need to adjust the view of the camera or you can also adjust the threshold to see more markers. If you have

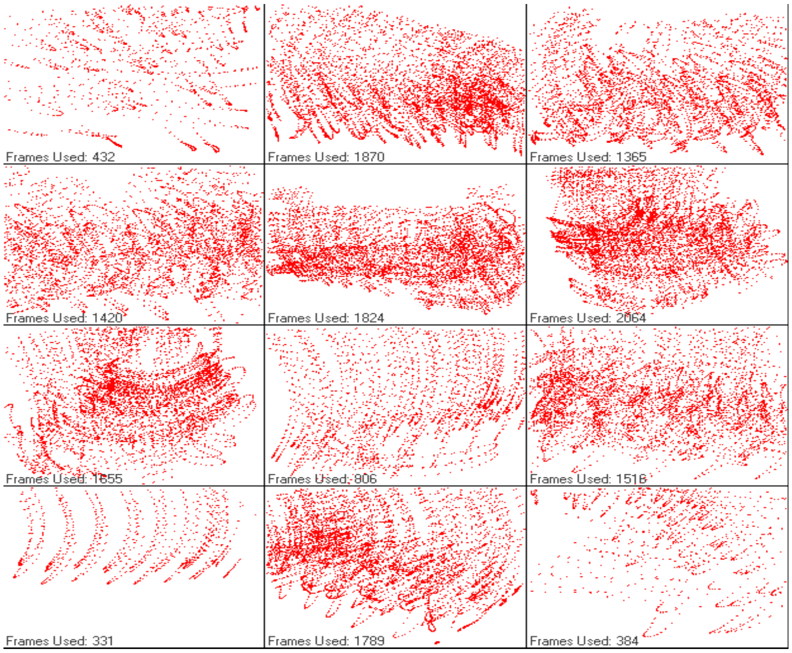
more, you can mask out extraneous data points. To mask, press **Pause.** While in one of the 2-D views, press the middle mouse button and hold it, then drag a square over the bad data to mask.

6. Check the 3-D display and camera locations.
   - If it is not already set, right-click and select **Show Cameras**. All of the cameras should be in the correct place.
7. Optimize the camera positions and their orientation.
   - New camera positioning should be done at this point if needed.
   - Right-click in the 3-D view and select **Show Camera Field-of-View**. You will probably have to change the length of the field of view to more than the default value of 4000 (4 meters). Try 9000 (9 meters).
   - Turn the capture volume on by right-clicking your mouse in the 3-D display and selecting **Show Volume**. This volume is a visual aid helpful in this process of aiming the cameras properly. The volume dimensions are entered under **Tools > Calibration Setting > Capture Volume** tab in the new window.
   - You camera field of view should cover the desired volume. Try and align edges of the volume box with edges of the camera field of view. This may require that one person moves the camera on 3 axes, while another person directs the movements.
8. Once the camera position is optimized, press the **Collect and Calibrate** button in the Calibration with Square field. If sound is enabled and you have speakers turned on, you will hear a sound.

Continue the Calibration Process Using the Calibration Wand

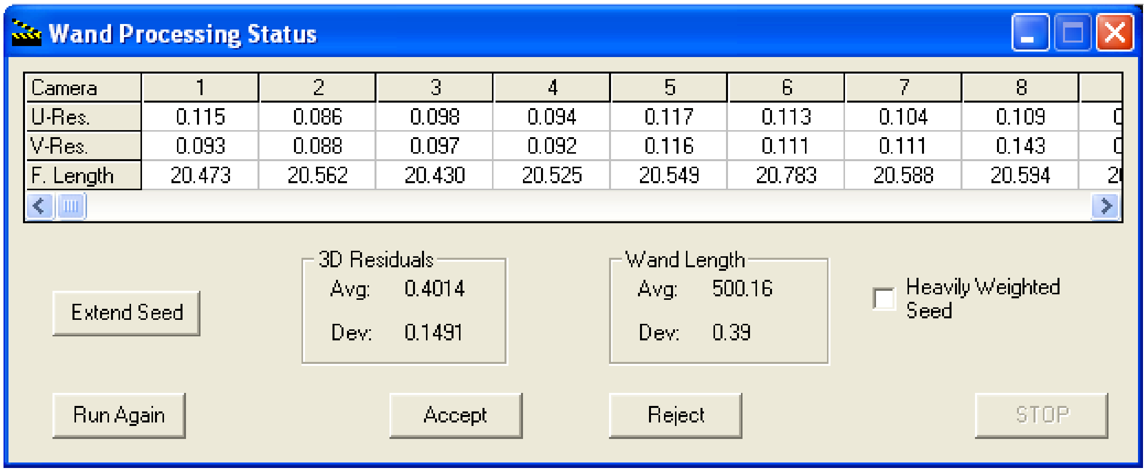
1. Remove the L-frame from the capture area. It will need to be completely out of view from all cameras.
2. Set the wand length in the **Calibration with Wand** field.
   - Make sure the wand length is set at 200mm or 500mm depending on the wand used.
3. Set the capture duration.
   - The wand capture duration should be around 60 seconds, or long enough to cover the capture volume. During the 60 seconds, 1/3 of the time should be spent waving the wand parallel to each axis: x, y, and z.
4. Press the **Collect and Calibrate** button in the Calibration with Wand field.
5. Begin waiving the wand to cover the capture volume as much as possible.
   - The object of this exercise is to cover the entire capture volume by waving the wand both horizontally and vertically through the cameras field of view. If you look at the 2-D fields of view, you should have only a small amount of white space. The better the coverage, the better the calibration.

Figure 2-3. Proper Wand Calibration Coverage



6. When finished, and the Wand Processing Status window appears, you should uncheck **Heavily Weighted Seed** and then press the **Run Again** button.
   - This will recalculate the calibration with more emphasis on the wand data, rather than the L-frame.

Figure 2-4. Wand Processing Status Window



Camera	1	2	3	4	5	6	7	8
U-Res.	0.115	0.086	0.098	0.094	0.117	0.113	0.104	0.109
V-Res.	0.093	0.088	0.097	0.092	0.116	0.111	0.111	0.143
F. Length	20.473	20.562	20.430	20.525	20.549	20.783	20.588	20.594

3D Residuals
Avg: 0.4014
Dev: 0.1491

Wand Length
Avg: 500.16
Dev: 0.39

☐ Heavily Weighted Seed

7. Check the calculated Focal Lengths.

- The Focal Length for each camera is calculated and should be close to the value that is set on the lenses.

8. Check the 3D Residual Values:

- The 3D Residual values should be fairly low depending on the type of cameras you have.The Standard Deviation should be approximately half of the 3D residual. Press the **Run Again** button until the values in the calibration processing window stop changing significantly.

9. When everything looks good and you are ready, press **Accept**. If the calibration still does not meet the desired values, you can press the **Reject** button. You may have to do one part or all of calibration again.

Note: It is possible to calibrate with previously collected files.

10. Save the project (**File > Save Project**).

- When you press **Accept** in the step above, you will get two messages stating "Calibration has been saved". This message indicates that the project is saved to a system folder. You need to select **File > Save Project** in this step, since the system folder will be overwritten each time a calibration is done.

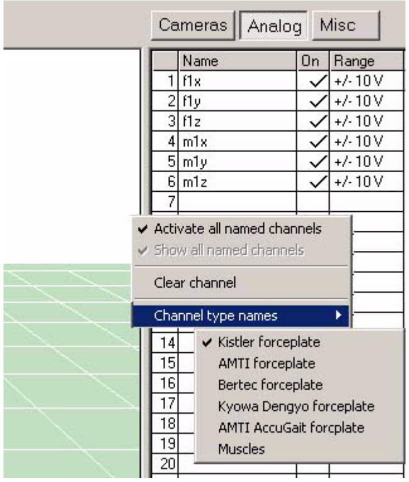
Possible Problems with Calibrations: How to Solve

- Wrong placement or measurements of the L-frame calibration square. Verify all measurements and x, y, and z axes that are set.
- Check the brightness of the cameras and the use/non-use of masks. Remember to limit the use of masks and make them as small as possible if they are in line from the camera through the intended capture volume. If any markers go through a masked area, the data will be ignored.
- Too many extra images in wand are possible causes for a bad calibration. Watch out for anything reflective such as extra markers, reflective material on shoes, shiny floors, debris in carpeting, and sunlight coming in through windows.
- If calibration problems persist, contact support@motionanalysis.com

Setup Analog

1. In the **Setup > Analog** sub-panel, right-click on the Name column. Scroll down to **Channel type names** and select the type of Force Plate that you are using or if you are looking at lower body muscles, select **Muscles**.

Figure 2-5. Setup > Analog Sub-Panel—Channel Type Names



	Name	On	Range
1	f1x	✓	+/- 10 V
2	f1y	✓	+/- 10 V
3	f1z	✓	+/- 10 V
4	m1x	✓	+/- 10 V
5	m1y	✓	+/- 10 V
6	m1z	✓	+/- 10 V
7			

Cameras
Analog
Misc
✓ Activate all named channels
✓ Show all named channels
Clear channel
Channel type names
✓ Kistler forceplate
AMTI forceplate
Bertec forceplate
Kyowa Dengyo forceplate
AMTI AccuGait forcplate
Muscles
14
15
16
17
18
19
20

2. If you are collecting forceplate data, then select one of the forceplate manufacturers and then select one of the FP1, FP2, FPx… choices available. These correspond to the number of forceplates you have available to use. This will automatically set 6 or 8 channel names (forceplate dependant) with default voltage settings for each forceplate selected.
3. For muscles, it will only bring up the muscle selected. The user may also specify their own name for an analog channel (e.g. upper body muscles).
4. The Range setting also has a drop down menu of varying excitation voltages.These setting should match your hardware (forceplates, EMG system, or other analog devices.)
5. Set your sampling rate at some value greater than the frame rate at which you are capturing video data.

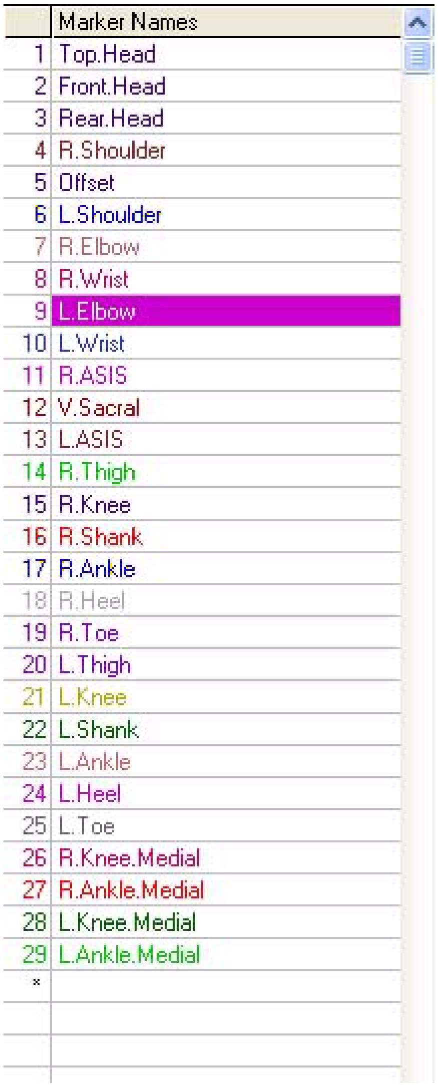
6. To activate the channel name, simply click in the On column corresponding to the analog channel. A check mark will appear when active.

Marker Placement

Note: For the purpose of this illustration, this example uses the Helen Hayes (both the static and dynamic) marker sets. The theory may be extended to different marker sets.

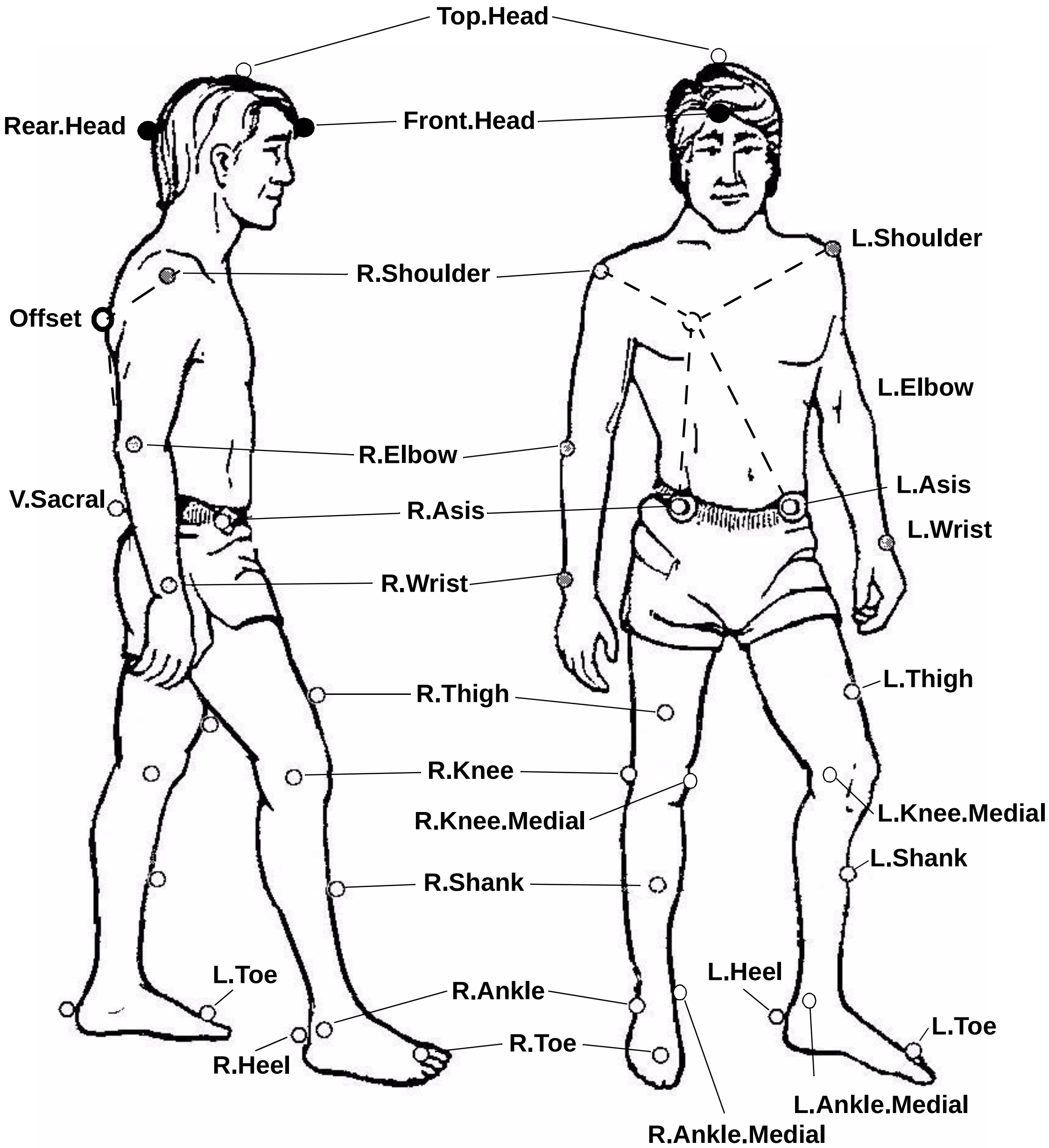
1. Attach the reflective markers that are listed in Figure 2-6 and shown in Figure 2-7. Placement on bony points is ideal if available. Consult an anatomy book as reference for palpating these points.

Figure 2-6. Helen Hayes Marker Set List



	Marker Names
1	Top.Head
2	Front.Head
3	Rear.Head
4	R.Shoulder
5	Offset
6	L.Shoulder
7	R.Elbow
8	R.Wrist
9	L.Elbow
10	L.Wrist
11	R.ASIS
12	V.Sacral
13	L.ASIS
14	R.Thigh
15	R.Knee
16	R.Shank
17	R.Ankle
18	R.Heel
19	R.Toe
20	L.Thigh
21	L.Knee
22	L.Shank
23	L.Ankle
24	L.Heel
25	L.Toe
26	R.Knee.Medial
27	R.Ankle.Medial
28	L.Knee.Medial
29	L.Ankle.Medial
*	

Figure 2-7. Helen Hayes Marker Set Placement


Top.Head
Rear.Head
Front.Head
L.Shoulder
R.Shoulder
Offset
L.Elbow
R.Elbow
L.Asis
V.Sacral
R.Asis
L.Wrist
R.Wrist
L.Thigh
R.Thigh
R.Knee
R.Knee.Medial
L.Knee.Medial
L.Shank
R.Shank
L.Toe
L.Heel
R.Ankle
L.Toe
R.Toe
R.Heel
L.Ankle.Medial
R.Ankle.Medial

Data Capture

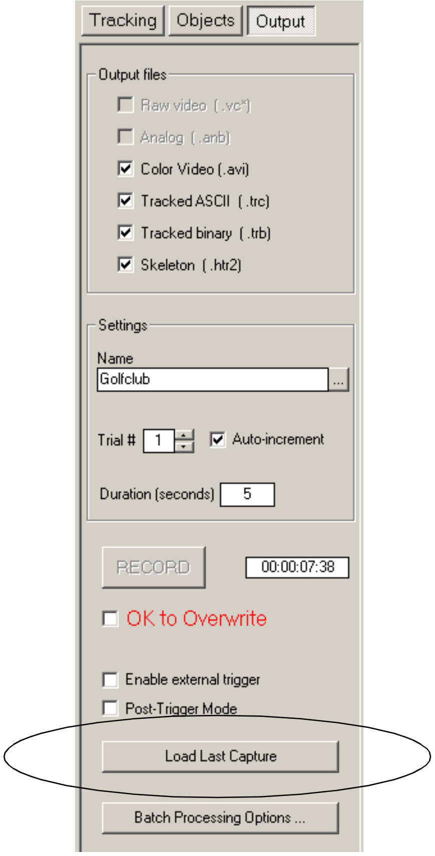
Capture a Static Trial

1. Go to the **Motion Capture > Output** sub-panel and activate the Raw Video (.vc), Tracked Binary (.trb), and Analog Binary (.anb) check-boxes.
2. Type in a filename (e.g. Static). Do not use a number at the end of the filename. The trial number gets appended to the filename. If you need to have a number in the filename, make sure you follow it with an underscore (Static1_) otherwise your first trial will be interpreted by the software as trial 11 not 1.
3. Set the duration to be 1 second. Have the patient stand in the center of capture volume with arms raised parallel to the floor, thumbs facing forward.
4. Press the **Record** button.
5. This will produce a **Static1.trb** file and an analog and raw video file of the same name.

Identify a Static File

1. Load **Static1.trb**.
   - Do this either by pressing the **Load Last Capture** button on the **Motion Capture > Output** sub-panel or go to **File > Load Tracks File,** then select and load it.

Figure 2-8. Motion Capture > Output Sub-Panel—Load Last Capture Button

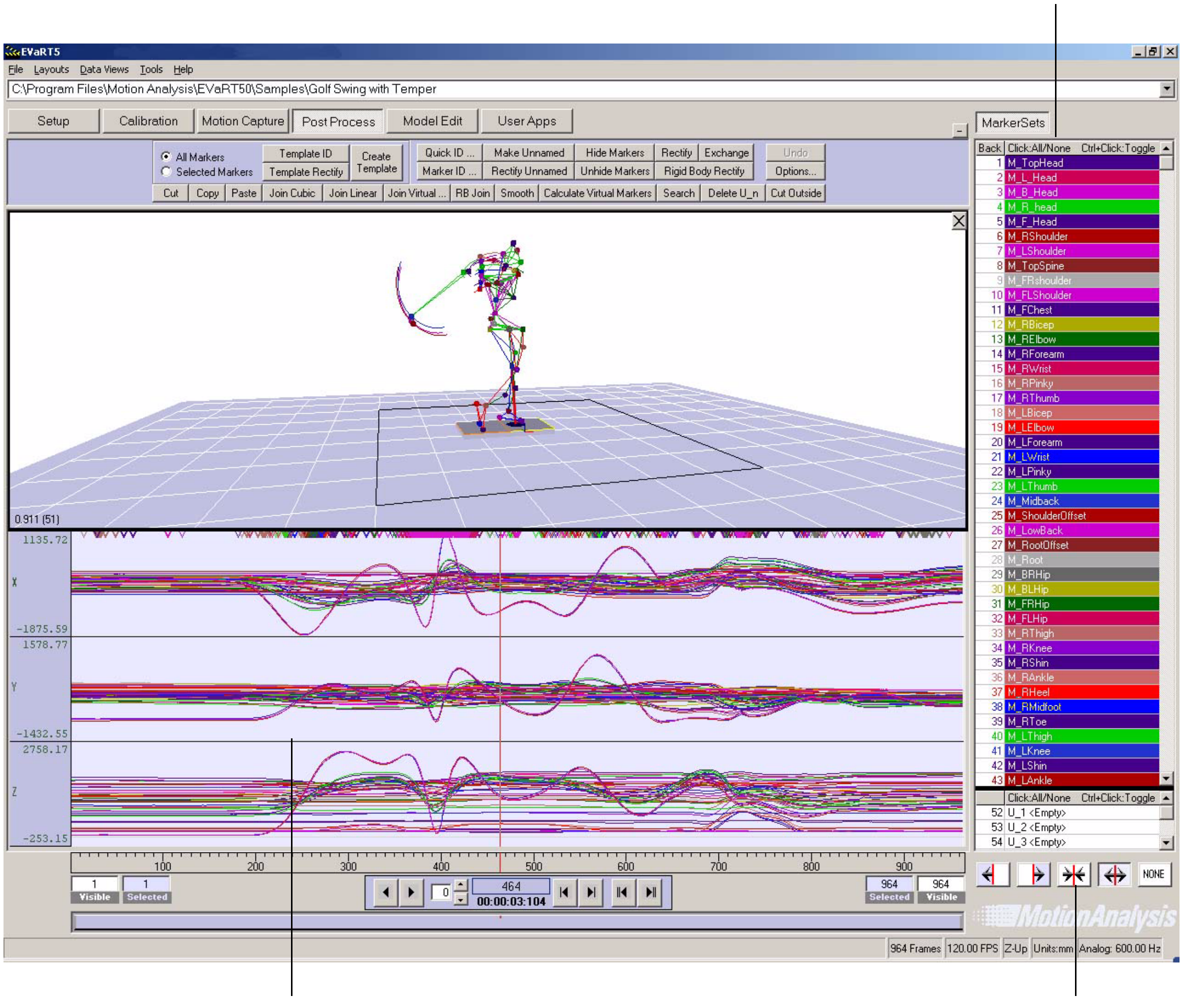


☐ Raw video (.vc*)
☐ Analog (.anb)
☑ Color Video (.avi)
☑ Tracked ASCII (.trc)
☑ Tracked binary (.trb)
☑ Skeleton (.htr2)

Name: Golfclub
Trial #: 1 ☑ Auto-increment
Duration (seconds): 5
00:00:07:38
☐ OK to Overwrite
☐ Enable external trigger
☐ Post-Trigger Mode

2. Loading a file will automatically bring you under the Post Process interface. Select the Identify sub-panel.
3. Press **Quick ID**. The Identifying window appears. Activate the **Rectify** check-box.
4. Identify each marker with the correct name.
5. Play the trial to make sure it is identified throughout the entire trial. If not, go to the frame you used for identification (usually frame 1) and press **Select Visible Frames** (shown in Figure 2-9) located in bottom right of screen and then press **Rectify**. Check again by playing the trial.

Figure 2-9. Post Process > MarkerSets Sub-Panel


EVaRT5
File Layouts Data Views Tools Help
C:\Program Files\Motion Analysis\EVaRT50\Samples\Golf Swing with Temper
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
MarkerSets
○ All Markers
○ Selected Markers
Template ID
Template Rectify
Create Template
Quick ID ...
Marker ID ...
Make Unnamed
Rectify Unnamed
Hide Markers
Unhide Markers
Rectify
Exchange
Rigid Body Rectify
Undo
Options...
Cut
Copy
Paste
Join Cubic
Join Linear
Join Virtual ...
RB Join
Smooth
Calculate Virtual Markers
Search
Delete U_n
Cut Outside
0.911 (51)
1135.72
X
-1875.59
1578.77
Y
-1432.55
2758.17
Z
-253.15
100
200
300
400
500
600
700
800
900
1 Visible
1 Selected
0
464
00:00:03:104
964 Selected
964 Visible
NONE
MotionAnalysis
964 Frames
120.00 FPS
Z-Up
Units:mm
Analog: 600.00 Hz

Back	Click:All/None Ctrl+Click:Toggle
1	M_TopHead
2	M_L_Head
3	M_B_Head
4	M_R_head
5	M_F_Head
6	M_RShoulder
7	M_LShoulder
8	M_TopSpine
9	M_FRshoulder
10	M_FLShoulder
11	M_FChest
12	M_RBicep
13	M_RElbow
14	M_RForearm
15	M_RWrist
16	M_RPinky
17	M_RThumb
18	M_LBicep
19	M_LElbow
20	M_LForearm
21	M_LWrist
22	M_LPinky
23	M_LThumb
24	M_Midback
25	M_ShoulderOffset
26	M_LowBack
27	M_RootOffset
28	M_Root
29	M_BRHip
30	M_BLHip
31	M_FRHip
32	M_FLHip
33	M_RThigh
34	M_RKnee
35	M_RShin
36	M_RAnkle
37	M_RHeel
38	M_RMidfoot
39	M_RToe
40	M_LThigh
41	M_LKnee
42	M_LShin
43	M_LAnkle

	Click:All/None Ctrl+Click:Toggle
52	U_1 <Empty>
53	U_2 <Empty>
54	U_3 <Empty>

Click: All/None Button

XYZ Graphs in Bottom Pane

Select Visible Frames Button

6. Make sure there are no unnamed markers or gaps in the data. If so, activate the XYZ Graphs or in the bottom pane.

   - Turn all markers on with the **Click: All/None** button, as shown in Figure 2-9.
   - Press the Select Visible Frames button again, then press the **Del_Un** button, which is located on the **Post Process** panel.
   - Finally, press the **Join Cubic** button.
7. Save this as a TRB file (**File > Save Tracks**).

Load a Walking (Dynamic) Marker Set

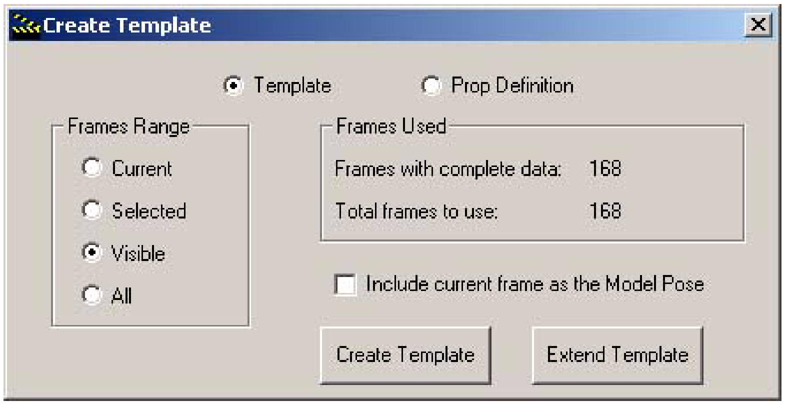
1. Select **File > Load MarkerSet**.
   - Load the **Walk.prj** file that contains the Helen Hayes Dynamic marker set. This will be the same marker set minus the medial knee and ankle markers.
2. Save the project (**File > Save As Project**) with your new name (i.e. Walk.prj), which will become the active project, as will be shown in the top, blue bar. This keeps the calibration for this capture session. You should now have two project files in the subject's directory.

Create a Template from the First Walking Trial

1. Select the **Motion Capture > Output** sub-panel. Activate the Raw Video (.vc) and Tracked Binary (.trb) check-boxes.
2. Type in a filename (e.g. Walk).
3. Set the duration to be long enough to record one full step cycle.
4. Press the **Record** button. This will produce a **Walk1.trb** file.
5. Next, load the **Walk1.trb** file.
   - Done by either pressing the **Load Last Capture** button in the Motion Capture > Output sub-panel or selecting **File > Load Tracks File**.
   - Loading a file will automatically bring you to the Post Process tab.
6. Select the **Post Process** panel, and then press **Quick ID**. An Identifying window appears. Activate the **Rectify** check-box.
7. Identify each marker with the correct name by clicking in the 3D view. The stick figure will automatically be drawn as you identify the markers and will help to highlight mistakes (gaps in data, marker misidentifying, swaps, ghost markers).
8. Play the trial to make sure it is identified throughout the entire trial. If not, go to the frame you used for identification (usually frame 1) and press **Select Visible Frames**, located in bottom right of screen and press then press **Rectify**. Check again by playing the trial.
9. Gaps in data can be filled by using Join Cubic and/or Join Virtual functions.

10. Press the **Create Template** button.

Figure 2-10. Create Template Interface



Create Template

● Template ○ Prop Definition

Frames Range

○ Current

○ Selected

● Visible

○ All

Frames Used

Frames with complete data: 168

Total frames to use: 168

☐ Include current frame as the Model Pose

The number of data frames should be at least 80% of the total number of frames. Save this **Walk1.trb** file (save over previous file). It now has the correctly identified marker names.

11. Save the tracks file by selecting **File > Save Tracks**.

12. Save project file by selecting **File > Save Project**.
  - The template becomes part of the project, yet the project still needs to be saved.

Extend Template

When you create a new template it uses only what is in the currently loaded tracks file to make the full template. When you extend the template, it also just uses what is currently loaded, but it doesn't throw out the existing template information. In effect, you are creating a new template from the original tracks file and the one you currently have loaded that has been combined into a single tracks file.

Extending a template will only increase the allowable range of motion in the linkages and never reduce them.

Collect the Walking Data

1. Go to the Motion Capture interface.
  - Collect the Walk trial. You may want to use a naming convention that adds a descriptor of the movement if your subject is doing multiple trials (e.g. Walk1.trb, Run1.trb, etc.).

2. If you are collecting force or EMG activity, activate the **Analog (.anb)** check-box.

Note: If you are using a Falcon/Midas system, you must start your analog data collection while connected to cameras and in pause mode. If you do not, you run the risk of being out-of-sync with your analog data. The reason for this is that the A/D board and the Midas are clocked differently, and over a period of time, cumulative drift will occur between the analog and video portion of the Motion Analysis system. This can be manually corrected in the Post Processing interface.

3. Set the capture duration.

- The duration should be representative of the length of the trial, typically 5-10 seconds.You can set the duration to be the maximum that you would ever expect, and then you could press the **Record**/**Stop** button for shorter, more typical trials.

4. Record the data.
   - Press the **Record** button.This will produce a **Walk1.trb** file as well as VCX and ANB files of the same name.
5. View the data.
   - To view analog data while collecting, choose the **2 Panes: Top/ Bottom** layout and set the top window to **3D Display**. Then set the bottom window to **Analog Display (Data Views > Analog Display).** You can now view one or all of the analog channels in this window.
6. Edit the data.
   - Editing is done using the **Data Views > XYZ Graphs.**
7. Save Tracks (**File > Save Tracks**)

This concludes this quick-start chapter for Movement Analysis applications (Helen Hayes/OrthoTrak marker set). If the Post Processing is to be done in the OrthoTrak software module, this requires TRB files for one static and up to several walking trials. The walking trials may also have their associated ANB files if analog (force and/or EMG) data has been collected.

Chapter 3

Quick-Start Tutorial for Animation Production Applications

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Starting EVaRT	3-1
Project Initialization	3-2
System Calibration	3-3
Marker Placement	3-8
Data Capture	3-9

Overview

This chapter provides a quick reference to begin using your motion capture system for Animation Production applications, and is intended for the more advanced motion capture system user. For Movement Analysis applications, refer to Chapter 2, Quick-Start Tutorial for Movement Analysis Applications.

Note: This Quick-start Guide uses an animation marker set and starts with a project file that is located in the **C:\Program Files\Motion Analysis\EVaRT 5.0\Samples\Animation Calibration** folder. The basic methodology outlined here can be generalized to other marker sets.

Starting EVaRT

1. Turn on the Host computer and login.
2. Turn on EagleHub(s) or Midas computer and turn on the cameras (analog system only).
3. Launch the **EVaRT** software by double-clicking the icon located on your computer’s desktop.

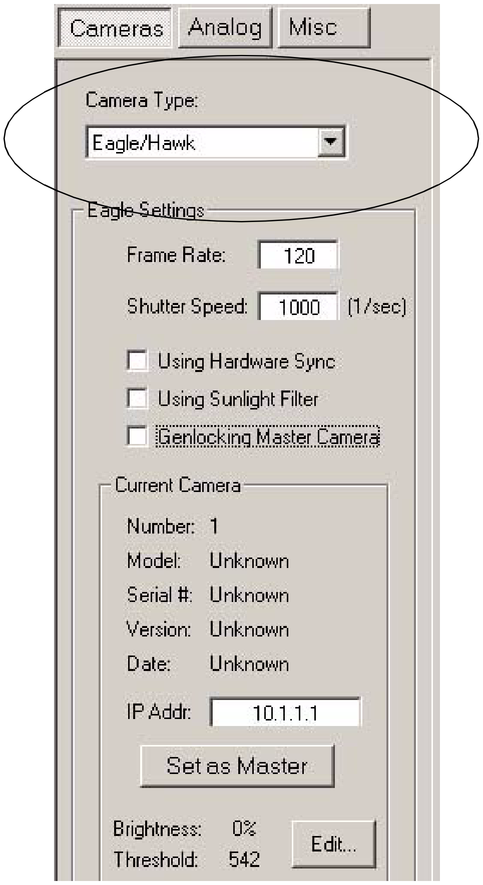
Project Initialization

1. Load a previous project (**File > Load Project**) that has an animation marker set.
    - Project files contain information about calibration, thresholds, masks, tracking parameters, marker sets, and templates.
    - By loading a previous project that contains all of this information, you will not have to re-enter it all each time you start a new capture session. You will only need to update the calibration.
2. Immediately save the project file in a new folder (**File > Save Project As...**).
    - Create a new folder for the subject and save your project there. This directory now becomes the default **EVaRT** directory.

Note: Make sure that you do not write over previous projects. Separate projects are needed in order to run trials for that particular day. If calibration VC files are written over, then recreating the calibration parameters in Post Process mode will not be possible.

3. In the **Setup > Cameras** sub-panel, choose the Camera Type.

Figure 3-1. Setup > Cameras > Camera Type



Camera Type: Eagle/Hawk

Frame Rate: 120

Shutter Speed: 1000 (1/sec)

☐ Using Hardware Sync

☐ Using Sunlight Filter

☐ Genlocking Master Camera

Number: 1

Model: Unknown

Serial #: Unknown

Version: Unknown

Date: Unknown

IP Addr: 10.1.1.1

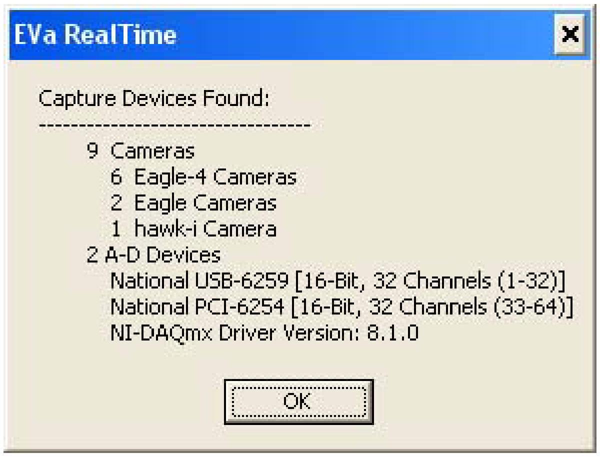
Brightness: 0%

Threshold: 542

- Under the Eagle/Hawk settings, choose **Frame Rate** and set the default shutter speed and brightness.
- Under the Falcon Camera settings, the user selects the camera and the camera speed simultaneously. Leave the default Midas settings.

4. Press **Connect to Cameras.**
    - The first time you do this step, a message indicating that "X number of cameras were found, existing project has 2. Do you want to modify project?" may appear. See Figure 3-2. Press the **OK** button.

Figure 3-2. Connect to Cameras Status Pop-Up (Example)



```
Capture Devices Found:
--------------------------------
    9  Cameras
         6  Eagle-4 Cameras
         2  Eagle Cameras
         1  hawk-i Camera
    2 A-D Devices
         National USB-6259 [16-Bit, 32 Channels (1-32)]
         National PCI-6254 [16-Bit, 32 Channels (33-64)]
         NI-DAQmx Driver Version: 8.1.0
```

System Calibration

Note: System calibration should be done at a camera speed of 60 Hz.

Start the Calibration Process Using the (4-Point) L-Frame Calibration Square

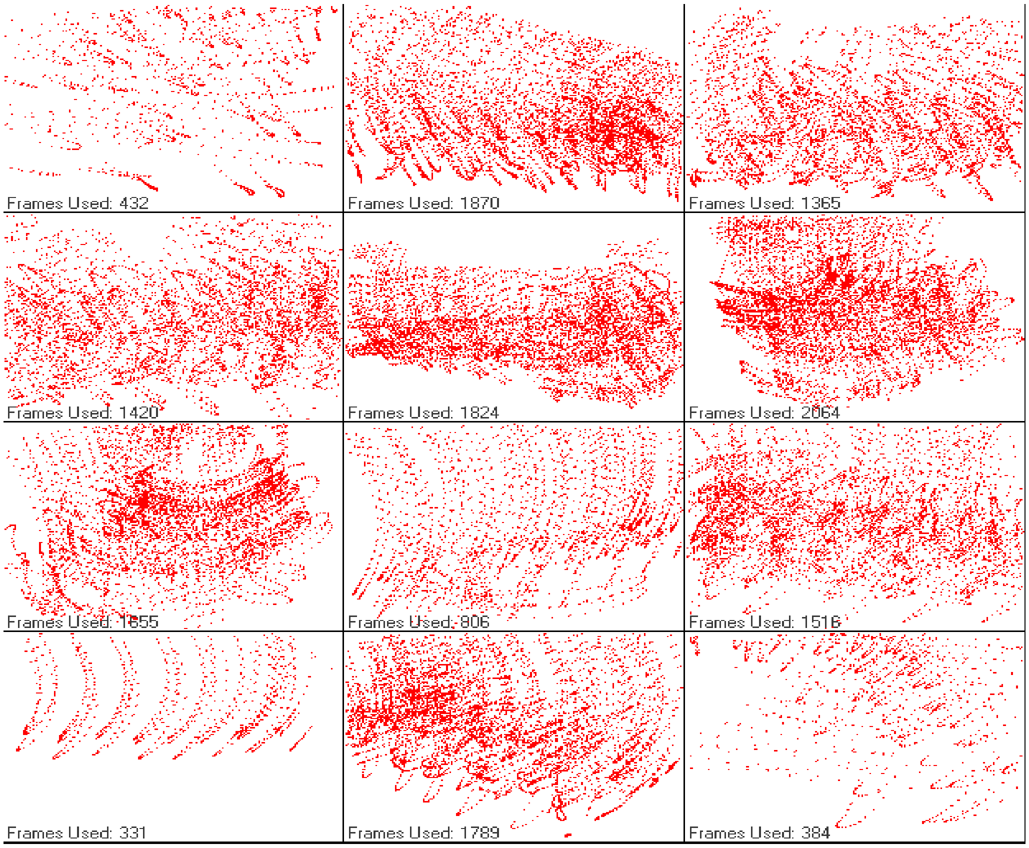
1. Place the calibration square device or four markers (L-shaped) on the floor or on the forceplate.
    - The Calibration Square markers are described under **Tools > Calibration Settings**. These markers have been placed in a particular orientation and precise distances apart in order to tell the software the origin and coordinate (XYZ) system of the lab/room.
2. Under the **Calibration > Calibrate** sub-panel, activate the Preview Calibration check-box.
3. Press the **Run** button.
    - All the number buttons on the bottom of the **EVaRT** interface should turn yellow if all of them can see the L-frame.
4. Select **Layouts > 2 Panes: Top/Bottom**.
    - We want the 3-D Display window and 2-D Display window showing. These can be set by left-clicking in the window to make it active and then select **Data Views > 3D Display** or **2D Display**.

5. Check the 2-D views on all the cameras.
    - There should only be four markers in each camera view. If there are less, you may need to adjust the view of the camera or you can also adjust the threshold to see more markers. If you have more, you can mask out extraneous data points. To mask, press **Pause.** While in one of the 2-D views, press the middle mouse button and hold it, then drag a square over the bad data to mask.
6. Check the 3-D display and camera locations.
    - If it is not already set, right-click and select **Show Cameras**. All of the cameras should be in the correct place.
7. Optimize the camera positions and their orientation.
    - New camera positioning should be done at this point if needed.
    - Right-click in the 3-D view and select **Show Camera Field-of-View**. You will probably have to change the length of the field of view to more than the default value of 4000 (4 meters). Try 9000 (9 meters).
    - Turn the capture volume on by right-clicking your mouse in the 3-D display and selecting **Show Volume**. This volume is a visual aid helpful in this process of aiming the cameras properly. The volume dimensions are entered under **Tools > Calibration Setting > Capture Volume** tab in the new window.
    - You camera field of view should cover the desired volume. Try and align edges of the volume box with edges of the camera field of view. This may require that one person moves the camera on 3 axes, while another person directs the movements.
8. Once the camera position is optimized, press the **Collect and Calibrate** button in the Calibration with Square field. If sound is enabled and you have speakers turned on, you will hear a sound.

Continue the Calibration Process Using the Calibration Wand

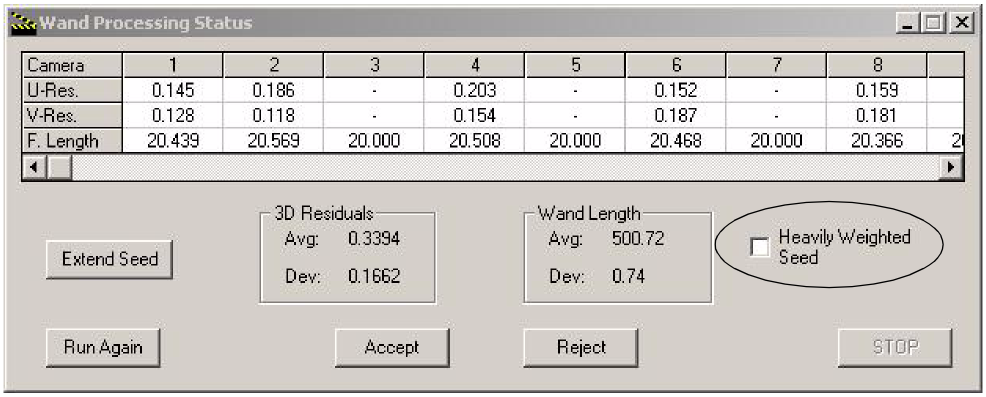
1. Remove the L-frame from the capture area. It will need to be completely out of view from all cameras.
2. Set the wand length in the **Calibration with Wand** field.
    - Make sure the wand length is set at 200mm or 500mm depending on the wand used.
    - You can also use previous CalWand VC files.
3. Set the capture duration.
    - The wand capture duration should be around 60 seconds, or long enough to cover the capture volume. During the 60 seconds, 1/3 of the time should be spent waving the wand parallel to each axis: x, y, and z.
4. Press the **Collect and Calibrate** button in the Calibration with Wand field.
5. Begin waiving the wand to cover the capture volume as much as possible.
    - The object of this exercise is to cover the entire capture volume by waving the wand both horizontally and vertically through the cameras field of view. If you look at the 2-D fields of view, you should have only a small amount of white space. The better the coverage, the better the calibration.

Figure 3-3. Proper Wand Calibration Coverage



6. When finished, and the Wand Processing Status window appears, you may uncheck **Heavily Weighted Seed** and then press the **Run Again** button. See Figure 3-4.
   - This will recalculate the calibration with more emphasis on the wand data, rather than the L-frame.

Figure 3-4. Wand Processing Status Window



Wand Processing Status

Camera	1	2	3	4	5	6	7	8
U-Res.	0.145	0.186	-	0.203	-	0.152	-	0.159
V-Res.	0.128	0.118	-	0.154	-	0.187	-	0.181
F. Length	20.439	20.569	20.000	20.508	20.000	20.468	20.000	20.366

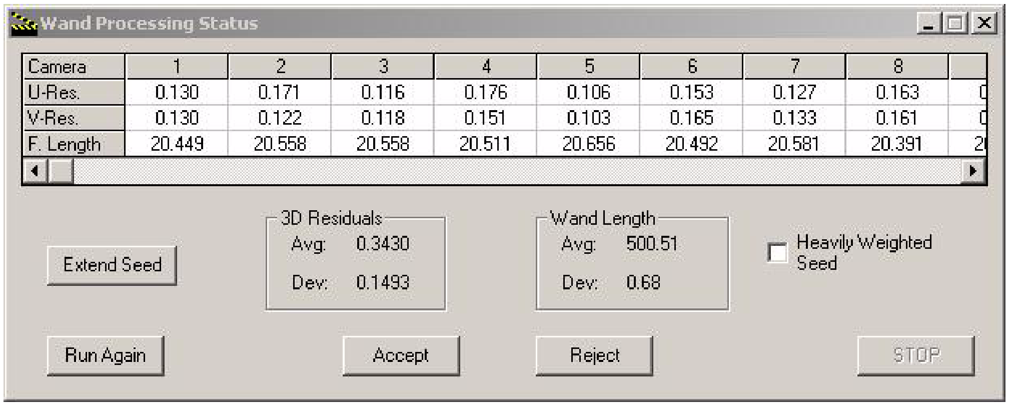
3D Residuals
Avg: 0.3394
Dev: 0.1662

Wand Length
Avg: 500.72
Dev: 0.74

☐ Heavily Weighted Seed

7. In this example (Figure 3-4), not all the cameras can see the seed device, so not all cameras have calibration values. Press the **Extend Seed** button to start the calibration process for the cameras that did not see the seed.

Figure 3-5. Wand Processing Status Window—After Extend Seed



Wand Processing Status

Camera	1	2	3	4	5	6	7	8
U-Res.	0.130	0.171	0.116	0.176	0.106	0.153	0.127	0.163
V-Res.	0.130	0.122	0.118	0.151	0.103	0.165	0.133	0.161
F. Length	20.449	20.558	20.558	20.511	20.656	20.492	20.581	20.391

3D Residuals
Avg: 0.3430
Dev: 0.1493

Wand Length
Avg: 500.51
Dev: 0.68

☐ Heavily Weighted Seed

8. Check the calculated Focal Lengths.
   - The Focal Length for each camera is calculated and should be close to the value that is set on the lenses.
9. Check the 3D Residual Values:

  - The 3D Residual values should be fairly low depending on the type of cameras you have.The Standard Deviation should be approximately half of the 3D residual. Press the **Run Again** button until the values in the calibration processing window stop changing significantly.

10. When everything looks good and you are ready, press **Accept**. If the calibration still does not meet the desired values, you can press the **Reject** button. You may have to do one part or all of calibration again.

Note: It is possible to calibrate with previously collected files.

11. Save the project (**File > Save Project**).

  - When you press **Accept** in the step above, you will get two messages stating "Calibration has been saved". This message indicates that the project is saved to a system folder. You need to select **File > Save Project** in this step, since the system folder will be overwritten each time a calibration is done.

Possible Problems with Calibrations—How to Solve

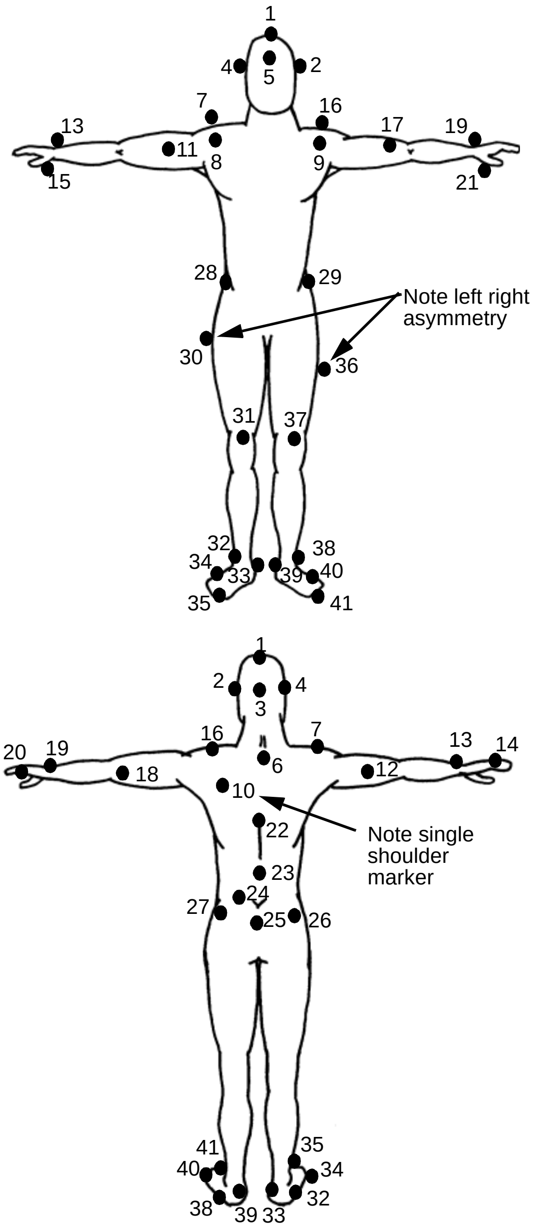
- Wrong placement or measurements of the L-frame calibration square. Verify all measurements and x, y, and z axes that are set.
- Check the brightness of the cameras and the use/non-use of masks. Remember to limit the use of masks and make them as small as possible if they are in line from the camera through the intended capture volume. If any markers go through a masked area, the data will be ignored.
- Too many extra images in wand are possible causes for a bad calibration. Watch out for anything reflective such as extra markers, reflective material on shoes, shiny floors, debris in carpeting, and sunlight coming in through windows.
- If calibration problems persist, contact support@motionanalysis.com

Marker Placement

Note: For the purpose of this illustration, this example uses a typical animation marker set. The theory may be extended to different marker sets.

1. Attach reflective markers following the markers listed in Figure 3-6. Placement on bony points is ideal if available. Consult an anatomy book as reference for palpating these points.

Figure 3-6. Typical Animation Marker Set


1
4
5
2
7
16
13
11
8
9
17
19
15
21
28
29
Note left right asymmetry
30
36
31
37
32
38
34
33
39
40
35
41
1
2
4
3
16
7
20
19
18
6
13
14
12
10
22
Note single shoulder marker
23
24
27
25
26
41
35
40
34
38
39
33
32

Note-When placing markers on end segments, the markers should not form a line and should not have mirror symmetry. Thus, thumb and hand markers should never be the same distance from the wrist marker and should be well separated.

Head and Neck

1. TopHead
2. L_Head
3. B_Head
4. R_Head
5. F_Head

Arms and Hands

11. RBicep
12. RElbow
13. RWrist
14. RPinky
15. RThumb
17. LBicep
18. LElbow
19. LWrist
20. LPinky
21. LThumb

Back and Root

22. MidBack
23. LowBack
24. RootOffset
25. Root

Shoulders and Sternum

6. TopSpine
7. RShoulder
8. FRshoulder
9. FLshoulder
10. ShoulderOffset
16. LShoulder

Pelvis and Hips

26. BRHip
27. BLHip
28. FRHip
29. FLHip

Legs and Feet

30. RThigh
31. RKnee
32. RAnkle
33. RHeel
34. RMidfoot
35. RToe
36. LThigh
37. LKnee
38. LAnkle
39. LHeel
40. LMidfoot
41. LToe

Data Capture

Load an Animation Marker Set

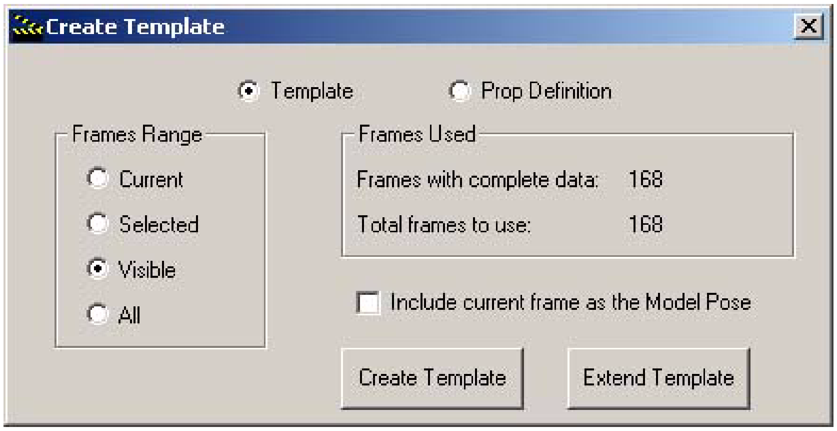
1. Select **File > Load Marker Set**.
    - Load the **MarkerSetBody.prj** file that contains the animation marker set.
2. Save the project file (**File > Save As Project**) with a new name (i.e. **Dave.prj**), which will become the active project, as will be shown in the top blue bar. This keeps the calibration for this capture session. You should now have three files in the project folder.

Create a Template from the First Walking Trial

1. Select the **Motion Capture > Output** sub-panel and activate the **Raw Video (.vc)** (if you're doing a live capture) and the **Tracked Binary (.trb)** check-boxes.
2. Create a range-of-motion (ROM) file. Type in a filename (i.e. DaveROM) and set the duration to be long enough to record one full step cycle. If you're using the example data, the program will know how long to record. For more information on the ROM files, refer to “Building a Template from the Range of Motion Trial” on page 9-5.
3. Press the **Record** button. This will produce a **DaveROM1.trb** file.
4. Load the **DaveROM1.trb** file.
    - Done by either pressing the **Load Last Capture** button in the **Motion Capture > Output** sub-panel or selecting **File > Load Tracks File**.
    - Loading a file will automatically bring you to the Post Process tab.
5. Select the **Post Process** panel and then press **Quick ID**. An Identifying window appears. Activate the **Rectify** check-box.
6. Identify each marker with the correct name by clicking in the 3D view. The stick figure will automatically be drawn as you identify the markers and will help to highlight mistakes (gaps in data, marker misidentifying, swaps, ghost markers).
7. Play the trial to make sure it is identified throughout the entire trial. If not, go to the frame you used for identification (usually frame 1) and press **Select Visible Frames**, located in bottom right of screen and press then press **Rectify**. Check again by playing the trial.
8. Gaps in data can be filled by using Join Cubic and/or Join Virtual functions.

9. Press the **Create Template** button.

Figure 3-7. Create Template Interface



Create Template
● Template
○ Prop Definition
Frames Range
○ Current
○ Selected
● Visible
○ All
Frames Used
Frames with complete data: 168
Total frames to use: 168
☐ Include current frame as the Model Pose
Create Template
Extend Template

10. Save the tracks file by selecting **File > Save Tracks**.

11. Save project file by selecting **File > Save Project**.

- The template becomes part of the project, yet the project still needs to be saved.

Start Collecting Motion Data

You are now ready to collect data for this subject.

Chapter 4 Planning a Motion Capture Session

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Studio or Lab Preparation	4-1
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Job Assignments and Tasks During the Session	4-3
Additional Equipment	4-4
Motion Capture Terminology	4-5
Motion Capture Session Sequence of Events	4-6
Capturing the Data	4-7

Overview

The motion capture process starts by collecting raw video data of the subject. The success of the final motion data will depend not only on the quality of the subject's performance but also on the organization skills and experience of the **EVaRT** operator. The quality of the **EVaRT** data can be greatly affected by the events leading up to and during the motion capture session.

An efficient motion capture session can ultimately save time and money. Although this chapter is geared towards animation, some information may be helpful for both animation and biomechanics. What follows are suggestions that can help make the motion capture session run smoothly.

Studio or Lab Preparation

At least a day before the capture session, the **EVaRT** user should know the capture volume required and the nature of the motion capture project. This information is essential for an efficient motion capture session. Knowing the capture volume allows for the advanced selection of the appropriate marker size for the session.

It may be appropriate to use different capture volumes for the different moves of a capture session. Changing the capture volume size and optimizing this volume could take up to one hour, so this switchover should be scheduled during a break. The approximate volumes can be set up ahead of time using tape on the floor to mark the capture volume boundaries and the position for the tripod legs (if used) of each camera.

If more than one subject will be performing in a capture session, it is a good idea to mark out a capture volume practice area away from the actual capture area. This will allow the next subject to practice before motion capture.

On the **EVaRT** host workstation, create the appropriate directories and project files. For batch edit work in Post Processing, a separate file folder for each project and its associated capture files is strongly suggested.

Make sure there is enough room on the **EVaRT** workstation's hard disk. If you know the number of trials you are going to capture and the approximate length of each trial, you can estimate the amount of hard disk space you will need. Use some form of backup medium (e.g. CD-ROM, Zip disk) to back up previous data and clear space on the hard disk for the new trials.

Prior to the Capture Session

Several days prior to the capture session, schedule a visit by the subject and any producers or directors involved in the motion capture session. If the subject has not worked with reflective markers, this will allow time to become familiar with marker placement and to practice in the marked-out capture area.

You will want to specify the most desirable type of clothing for the session. Remember, your goal is to capture the fine details of the movement of the body, not the movements of clothing on the body. The rule is to apply markers to skin whenever possible. The areas on the body that present the greatest potential problems are shoulders, the rear neck, sternum, mid back, and the root. A tank-top shirt may be used to expose the shoulder, neck, and sternum. The root marker should be placed low on the spine in an area below the belt line where there is usually very little clothing movement. If a mid back marker is used, the shirt should be rolled up and taped to expose the back. If skin cannot be exposed for all marker placements, then tight fitting clothes or a motion capture body suit should be worn.

Have the subject perform some of the motion capture moves within the capture area. If markers have been placed on the subject, go ahead and capture some data. This would be an ideal opportunity to use a stopwatch to time the duration of each move. These trials can give the **EVaRT** user an indication of potential tracking problems, and if this data is taken all the way to the animation software, it will allow the artist to see how well the data fits their models.

Finally, instruct the subject to speak up during the motion capture if there are any problems with the markers. If markers become loose, they will need to be reconnected more securely with tape or rubber bands.

Job Assignments and Tasks During the Session

Director

The director ensures that everyone involved is prepared for the capture session and controls the session, including instructing and critiquing the subject’s performance.

Camcorder Operator

The video recording from the camcorder can be very important documentation to aid in choosing the best takes. A video recording may also be useful for post-production promotions. An optional reference video capture is available. Refer to “Digital Video Option (EVaDV Software)” on page 6-21.

The camcorder should not be allowed to run during the entire capture session. This means that someone should be assigned to start and pause the camcorder for each take.

The camcorder operator should slate each of the takes. This involves recording the take number, the **EVaRT** trial name and number, and any other relevant information on a slate board. After starting the camcorder and before each take, the slate board is held up in front of the camcorder for a few seconds. The audio on the camcorder can also be used. When the slate is held up in front of the camcorder the operator can say the take number, the **EVaRT** filename, and any other information necessary. When the take is complete, the director can make audio comments on the quality of the take.

Scribe

Someone should be assigned to take notes and to fill in the Motion Capture Log. A sample of this log is found in Appendix M, Useful Blank Forms.

The take number, **EVaRT** file name, and the duration of the take and any comments from the director or subject should be recorded. The scribe can also do a time check using a stop watch to get the length of data capture for each new move.

EVaRT Operator

The **EVaRT** operator must make certain that the motion capture data is clean and trackable. The **EVaRT** operator must make sure the camera calibration is good and that raw calibration data is collected at various times throughout the session as insurance. This is particularly important when there are several people around and a camera might get bumped accidentally. The operator should watch for reflections, changing light conditions, such as sunlight coming through a window, or other external variables which may affect a capture.

Additional Equipment

Props

If the motion capture session requires the use of props, this must be known to all parties well in advance. The type of prop and its use are very important because reflective markers may have to be attached to the prop as well as the subject. One marker may be used to track position, but as many as three markers may be required to show all rotations of the prop. Many props that would ordinarily seem simple become very difficult to deal with during a motion capture session. A good example is the use of a ball as a prop. If a small ball is only being held, one marker may be used to track position. If a large ball is being bounced, three markers may be required to show all rotations.

Reflective or glossy material should **not** be used in the construction of props, and very large props may occlude the subject's markers. Remember, the design of the prop and how it affects the subject's movement are more important than the prop's physical appearance. Props may also be assigned separate templates (see "Multiple Tracking Objects" on page 9-7).

Camcorder

Used to completely document each trial, a camcorder will allow the producer to rank the trials of a move and will also give the animation artist something to use as a reference for the completed animation. See also "Digital Video Option (EVaDV Software)" on page 6-21.

Still Camera

Photographs of the subject, with markers attached, will help the artists understand the correspondence between the marker data and the actual figure.

Slate Board

A slate board and chalk or grease-pen board will provide an easy way to relate the camcorder record to the **EVaRT** data.

Markers, Tape, Pre-tape Liquids, Rubberbands

An adequate supply of reflective markers, double stick tape, paper tape, and "Tuff Skin" or "New Skin" should be available. For rough and tumble sessions, the best method to adhere markers is by using Velcro™ on a skin-tight motion capture suit. However, markers can be applied directly the skin.

If markers must be placed directly on the skin and the subject will be performing athletic moves in which perspiration might be a problem, pre-tape liquids like "Tuff Skin" or "New Skin" can help make double-stick tape adhere better. These products must be applied to dry skin and allowed to set for a minute or two before the marker is attached.

Rubberbands looped around the marker and limb also work well to stabilize the markers. Rubberbands can be looped together to increase diameter and prevent restriction of blood flow. Rubberbands can be used around the elbows, wrists, hands, knees, ankles and toes.

Backup Media

Spare CD-ROMs, Zip disks, or some other backup medium should be available for backups and data transfers.

Motion Capture Body Suit

A motion capture body suit with Velcro attachments for markers provides a quick way to prepare a subject for motion capture. The use of the body suit is especially effective when subjects are involved in rough or contact-type motion capture sessions, common in animation applications.

Camcorder Tapes

Depending on the length of the capture session, spare video tapes should be on hand.

Music Player

Either a CD or tape player can provide musical accompaniment. Music helps calm and smooth out the subject’s performance not only with dance, but athletic moves as well.

Stop Watch

A stop watch is handy for calculating the duration of each new move.

Sample Form

You should decide at the outset whether you will build a hierarchical skeleton. If you decided to, there are two software methods available: **SkB (Skeleton Builder)** and **Calcium/Si.**

Blank forms to help you define skeleton parameters for each of these methods can be found in Appendix M, Useful Blank Forms. You may want to copy one of these forms for recording your project measurements.

Motion Capture Terminology

Some terms that are useful to a motion capture session are **moves, trials,** and **takes**.

Move

A **move** is an event or routine performed by the motion capture subject. A move can be as simple as a neutral stance position, or as complex as a 2 person, 30 second dance routine. The director and subject will work from a **move list**.

Trial

Multiple **trials** of a move should be taken. The number of trials depends on the complexity of the move, the subject’s performance, and quality of the **EVaRT** raw data. Usually, three trials per move is adequate. It is important that the director or subject’s comments about the quality of the trial (which trial was the best) be recorded on the Motion Capture Log. Knowing which trial of a move is the best will allow the **EVaRT** user to track only the best trial.

Take

A **take** is the master number used to relate what is on the camcorder’s video tape to the **EVaRT** filenames and trial numbers. The **take number** is displayed on the slate board and on the Motion Capture Log. Every new image recorded on the video tape should have a new take number. This should include calibration collection, initialization and T-pose/Init pose stance positions. You should never re-use or redo a take number. If a data collection is aborted for some reason, e.g. a marker fell off, then the **EVaRT** filename and trial number can be overwritten, but the take number should change.

Motion Capture Session Sequence of Events

The Day Before:

1. Optimize the camera positions and orientation to the capture volume.
2. Calibrate the volume of the capture area.
3. Determine the correct marker size to use. **EVaRT** raw data should show 2 lines or greater per marker.
4. Setup the **EVaRT** project with the correct markers, virtual markers, linkages, segments, etc.
5. If possible, collect and track the markers on a person to verify that the tracking parameters are optimal.
6. Verify that there is enough space on the workstation's hard disk. If there is not enough space, back up the previous files and then erase them from the hard disk.
7. Organize the markers, tape, and props to most efficiently facilitate the session.

The Day of the Motion Capture

Before the subject arrives:

1. Load the **EVaRT** project.
2. Optimize the threshold settings.
3. Collect calibration data sets (both seed and wand).

Subject Preparation

1. Ensure subject's clothing is appropriate.
2. Allow the subject to warm up.
3. Attach the markers according to predetermined placements.

Note: Asymmetrical marker placement on the subject is critical for obtaining the best marker data.

4. With the markers in place, take still photos of the subject from the front, side, and rear view.

Note: If you are taking photographs, do not use the flash attachment on the still camera while you are collecting data. A flash during data collection can corrupt the data.

5. Allow the subject to practice in the capture volume with the markers on.
6. Prepare for the calibration collection. Explain to everyone the importance of not bumping the camera tripods.

Capturing the Data

Calibration

Note: This section provides a general overview of the calibration process. For complete calibration information, refer to Chapter 8, Calibration Panel.

Collect the Square (Seed) Calibration

1. Fill out the Motion Capture Log and slate board for the first square (seed) calibration. This would be Take 1 and an **EVaRT** filename, for example "**CalSeed**".
2. Prepare the **EVaRT** system for data collection. Press the **Collect and Calibrate** button to trigger the event button.
3. Verify that the camera buttons turn yellow after the Seed calibration is complete.
4. Remove the calibration seed device (calibration square) from the capture volume.

Collect the Wand Calibration

For best results it is recommended that you collect and use wand calibration data.

Prepare the **EVaRT** system for wand calibration. The duration of the wand calibration is directly correlated to the capture frame rate. A typical duration for a small capture volume is 30 to 60 seconds. Large volumes with ten or more cameras can take 120 to 180 seconds, and very large volumes may take up to 240 seconds.

Collect and verify that the wand calibration data is good. It may be necessary to reposition or move cameras and to retake both the seed and the wand calibration data if one or more cameras has large areas without wand calibration data. You will also want to uncheck the **Heavily Weighted Seed** check-box, and press **Run** again. Keep pressing **Run** after it finishes, until the calibration numbers stop changing.

Your wand data should cover the entire capture volume. A common method of ensuring better wand data is to use a 1/3 method. That is, hold the wand markers in alignment along each axis (X, Y, and Z) for 1/3 of the wand capture session.

Collecting Trial Data

Subject Initialization

The type of subject initialization depends on the application.

- In animation applications it is the "T-Pose" or "Init Pose" trial
- For **OrthoTrak** it is the Static Trial
- For **KinTrak** it is the Neutral Trial

In general, the procedure is as follows:

1. Have the subject stand in the capture volume with the markers on. On the **EVaRT** system. Look for any reflection and light source that might interfere with the capture and correct the problem.
2. Prepare the **EVaRT** system by entering a filename. If the subject's name is Jane use something like JaneInit1. For this initialization file, use a duration of 2-3 seconds. The take number should be set to 3. Click on **Collect** to arm the event button. You can enter a long duration (e.g. 20 seconds) and then press the hand-held event button a second time at the end of the move.
3. Update the slate board with the new take number and **EVaRT** filename. Make the same entries in the Motion Capture Log.
4. When everybody is ready, the director can say "roll video", then slate the video. Now the **EVaRT** operator gives the signal for the subject to start and presses the event button to start the data collection. The event button must be pressed a second time to stop data collection at the end of the move.
5. For initialization, use the T-pose/Init pose. In this pose the subject faces forward and raises both arms straight out from their sides with the thumbs oriented up. Perform this motion within the duration of the capture time.
6. Pause the camcorder.
7. Collect two trials of this "initialization" move.

Capturing the Moves

1. Before capturing, have the subject practice each move.
2. Enter a duration **longer** than the estimated length of the move.
3. Enter an **EVaRT** filename, the duration of data capture, the trial number and trigger the Event button.
4. Update the slate and the Motion Capture Log.
5. The director should ask if everybody is ready and then say:
   "Roll video", "Slate video."
6. The **EVaRT** operator presses the event trigger button and the subject begins the trial. When the trial is finished, the event trigger button is pressed again to complete the capture.
7. Comments on the quality of the trial should be entered into the Motion Capture Log and on the audio of the camcorder.
8. The **EVaRT** operator quickly reviews the raw data and looks for any problems.
9. This process is usually repeated for 3 trials of each move that is scheduled.

Note: Usually only one trial is tracked. The other trials are there for insurance and to allow the end user to pick the best trial.

Collecting Calibration "Insurance" Data

For insurance, it is a good idea to periodically collect raw calibration data whenever there is down time. As the number of people increases in the capture studio, the chance for bumping a camera (if tripods are being used) increases and "insurance" calibration data suddenly becomes very valuable.

Wrapping It Up

After all the trials have been collected, perform the following to wrap up the process:

1. Collect the last calibration trial.
2. Backup all the **EVaRT** trials on a CD-ROM, Zip disk, or other backup medium. Label and store the tape in a safe place.
3. Remove the video tape from the camcorder and set the safety tabs on the tape to prevent being recorded over.
4. Consolidate and make copies of the motion capture logs and forms.
5. If necessary, give the video tape and Motion Capture Logs to the director so the best trials of each move can be indicated.
6. Place logs and offset forms in a binder. Clear plastic inserts can be added to hold the still photos. The binder along with the video tape will provide important information to both the **EVaRT** user tracking and editing the data, and for the artists who will apply the final data to the model.

Chapter 5

Camera Setup

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Setting Up a Motion Capture Laboratory

Camera placement is the most important aspect of setting up your motion capture laboratory. If properly done, good camera placement will reward you with highly accurate and consistent results, and greatly reduced editing time.

Optimum Laboratory Conditions

- Fluorescent lights are the best ambient light when red or notch filters are used on the motion capture cameras.
- Windows should be covered with curtains to eliminate direct outside light.
- Carpeting or other non-shiny floor surfaces are preferable to tile flooring which can reflect opposite ring lights.
- For analog cameras (Falcon, Cohu, etc.), power outlets should be located within ten feet of each camera’s tripod, or extension cords may be used.

Recommended Supplies

- A stepladder—for adjusting the cameras/tripods.
- Masking tape—to mark the floor when measuring the capture space and setting up the cameras.
- Reflective markers—to attach to the subject and also enough to place on the floor when adjusting the cameras.
- Other supplies include surgical tape, electrode collars for applying markers to people and gaffer’s tape (black masking tape).

Deciding On the Optimum Number of Cameras

There are several objectives to consider when deciding how many cameras should be used and where they should be placed.

1. There should be a sufficient number of cameras to insure that, at all times, all markers will be visible by at least two, and preferably three, cameras. In general, the number of cameras must be increased when:
   - the motion of the subject becomes less constrained
   - the number of subjects or objects increases
   - the capture volume increases
2. As more cameras are used, each camera should view only a portion of the capture volume to achieve higher accuracy and prevent too many cameras from seeing any one marker. The only requirement is that all 4 markers on the Calibration Square should be visible in at least 1/2 of the cameras. You can then use the Extend Seed function (see "Extending the Seed Calibration" on page 8-18).

Note: When more than 5 or 6 cameras see the same marker, the accuracy of tracking is not increased and computation time increases.

3. Camera views should not include areas outside the capture volume to ensure the highest possible spatial resolution.

The number of cameras in a typical motion capture setup can be as few as 3 or as many as 64. The following provides some guidelines for deciding on the number of cameras to use. In the following figures, all measurements are in meters.

6 Cameras

For motion capture involving only one subject, where the occlusion of markers is not a problem, six cameras may be adequate. This configuration is often used for gait analysis and other similar biomechanical applications. The two end cameras are often tilted so that the long axis of the view areas is vertical. For optimum results, all cameras should be about 2.5 meters above the floor. See Figure 5-3.

8 Cameras

As a wider range of motion is allowed, the probability of markers being occluded increases to the point that eight or more cameras are required. This is the minimum recommended configuration for animation applications. Cameras should be about 3 meters above the floor. See Figure 5-4.

10 Cameras

In an elongated capture space, ten cameras may prove beneficial. The first 8 cameras should be placed about 3 meters above the floor as in the 8 camera setup. The two additional cameras (9 and 10) should be placed 5 meters above the floor at each end of the long dimension of the capture volume and will probably have longer focal length lenses than the other cameras. See Figure 5-5.

12 Cameras

As the capture volume becomes more elongated, twelve cameras may be required. The first 8 cameras should be placed 3 meters above the floor. Cameras 10 and 11 should be placed as 5 meters above the floor on the ends of the capture volume but closer to the center than cameras 9 and 12. Therefore, one end of the long volume will be covered best by cameras 9 and 11, while the other end will be covered best by cameras 10 and 12. See Figure 5-6.

14 Cameras

When the sides of the capture volume are too long to be adequately covered by four cameras on each side, an additional pair of cameras with wide angle lenses can be placed in the center of each long side of the capture volume. The first 8 cameras should be 3 meters above the floor. Cameras 9 through 14 should be 5 meters above the floor. See Figure 5-7.

16 Cameras

To use more than 14 cameras effectively it is usually necessary to break the capture volume into two overlapping sections across the long axis. Each section is calibrated separately with its own square. Two squares can be used simultaneously or one square can be placed in two carefully measured positions in sequence. Every camera must see at least one of the squares in its entirety. All cameras should be placed 3 meters above the floor. See Figure 5-8.

For more information and an example, refer to "Overview of the System Calibrating Process" on page 5-20.

More than 16 Cameras

As capture volumes increase in size, more than 16 cameras may be required. It is best to consider the capture volume as two or more overlapping regions. For large square shaped capture volumes, up to 32 cameras can be used with the space broken into four regions. See Figure 5-9.

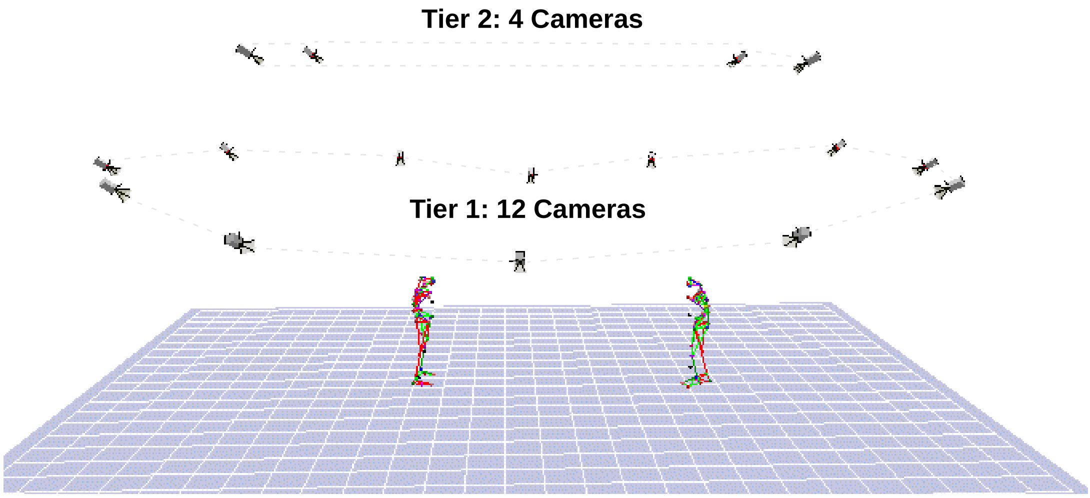
Capture Volumes Between Eagle and Hawk Cameras

Eagle and Hawk cameras use the same high-powered ringlights and have the same limits for marker distances. The difference between the two cameras is that you can use smaller markers with the Eagle cameras (about one-half the size of the Hawk markers).

16 Camera, Two-Tier Setup

For an example of this 16 camera, two-tier setup, open the **MAS_16Camera_2Tier.prj** file in the following directory: **C:\ProgramFiles\MotionAnalysis\EVaRT50\Samples\LargeVolumes** Also refer to Figure 5-1.

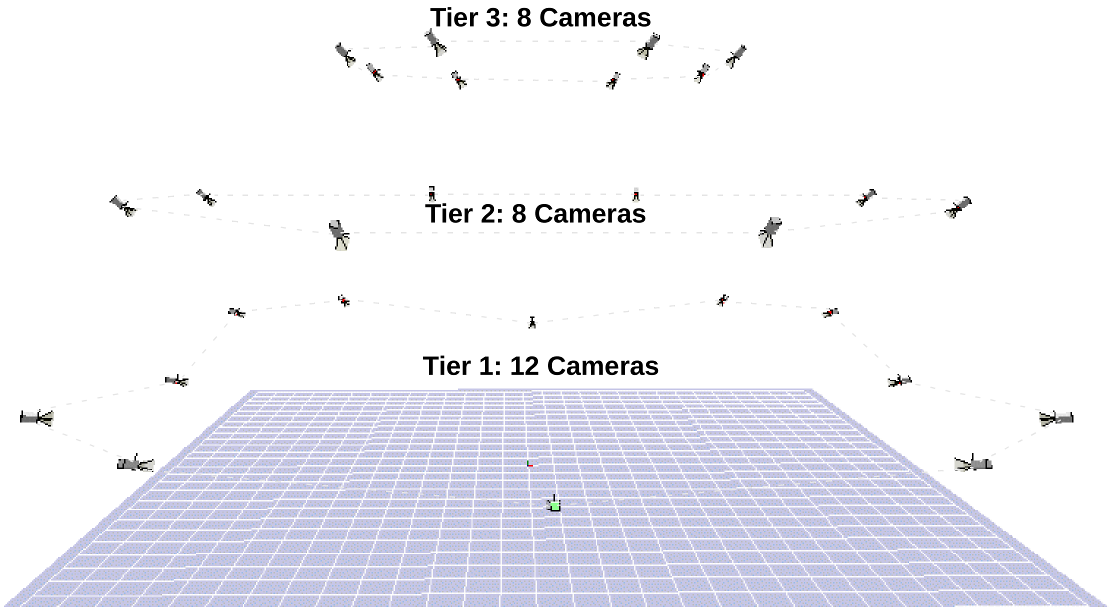
Figure 5-1. 16 Camera, Two-Tier Setup



28 Camera, 3-Tier Setup

For an example of this 28 camera, three-tier setup, open the **Spectrum_28Camera_3Tier.prj** file in the **C:\ProgramFiles\MotionAnalysis\EVaRT50\Samples\LargeVolumes** directory. Also refer to Figure 5-2.

Figure 5-2. 28 Camera, 3-Tier Setup



Ideal Capture Volume Sizes

Calculating the ideal volume size for a specific camera setup can have many factors involved and it can become a very hard question to answer. However, a good starting point would be to assume a two person, full body capture area in an ideal space (no restrictions on camera placement, etc.). For this we suggest the figures listed in Table 5-1.

Table 5-1. Ideal Volume Sizes for Specific Eagle and Hawk Camera Setups (with standard lenses[a])

Number of Cameras	Dimensions (m)	Area (m^2)
6	5 x 2	10
10	7 x 5	35
14	9 x 6	54
16	13 x 6	78
32	13 x 11	143

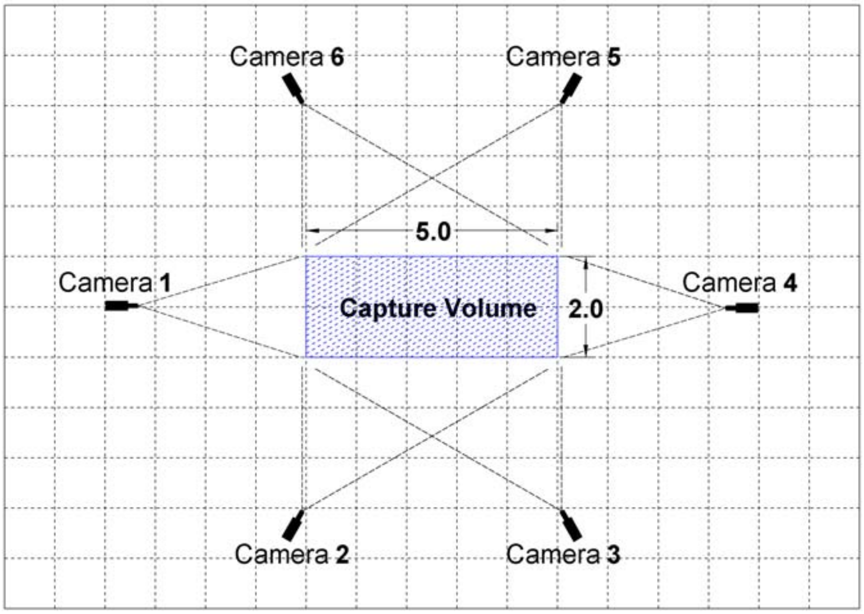
---

[a] Standard lenses are 18-35 mm Zoom for Eagle cameras, and 6 mm C-Mount for Hawk cameras.

So how is it that 16 cameras give you 4 times the capture area of 8 cameras (you might ask)? Mostly because when using a small number of cameras you end up wasting a lot of the usable viewing cone of each camera. Using more cameras allows for more efficient usage of each individual camera.

Table 5-1 is for Eagle and Hawk cameras. For Falcon cameras, you should multiply each dimension (each side) by about 0.8, which gives you 64% of the capture area compared to the same number of Eagle and Hawk cameras.

Figure 5-3. Typical 6 Camera Setup



Note: Capture volumes may vary depending on room size and the distance from the camera to the capture area.

Figure 5-4. Typical 8 Camera Setup

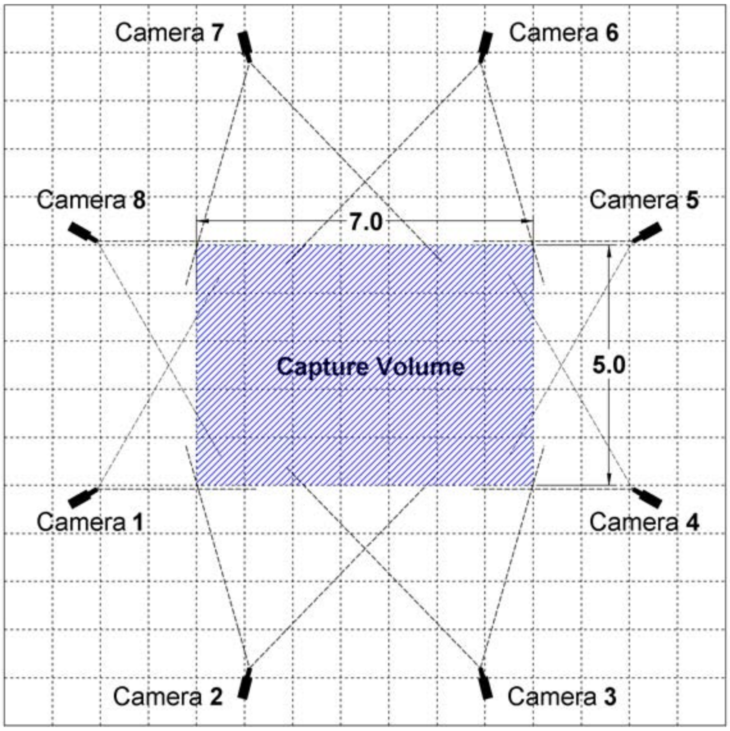

Camera 7
Camera 6
Camera 8
Camera 5
7.0
Capture Volume
5.0
Camera 1
Camera 4
Camera 2
Camera 3

Figure 5-5. Typical 10 Camera Setup

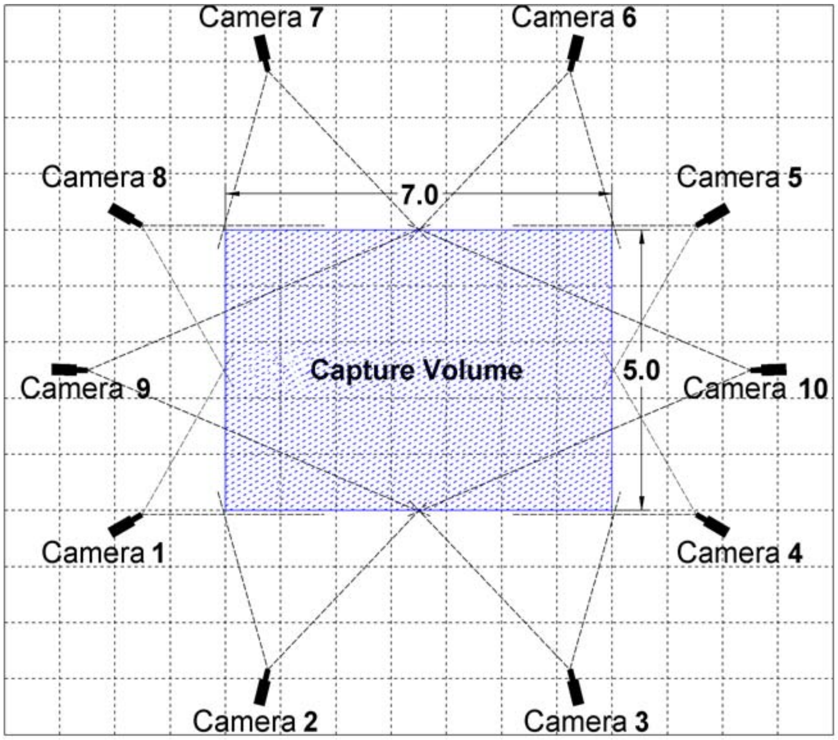

Camera 7
Camera 6
Camera 8
Camera 5
7.0
Capture Volume
5.0
Camera 9
Camera 10
Camera 1
Camera 4
Camera 2
Camera 3

Figure 5-6. Typical 12 Camera Setup

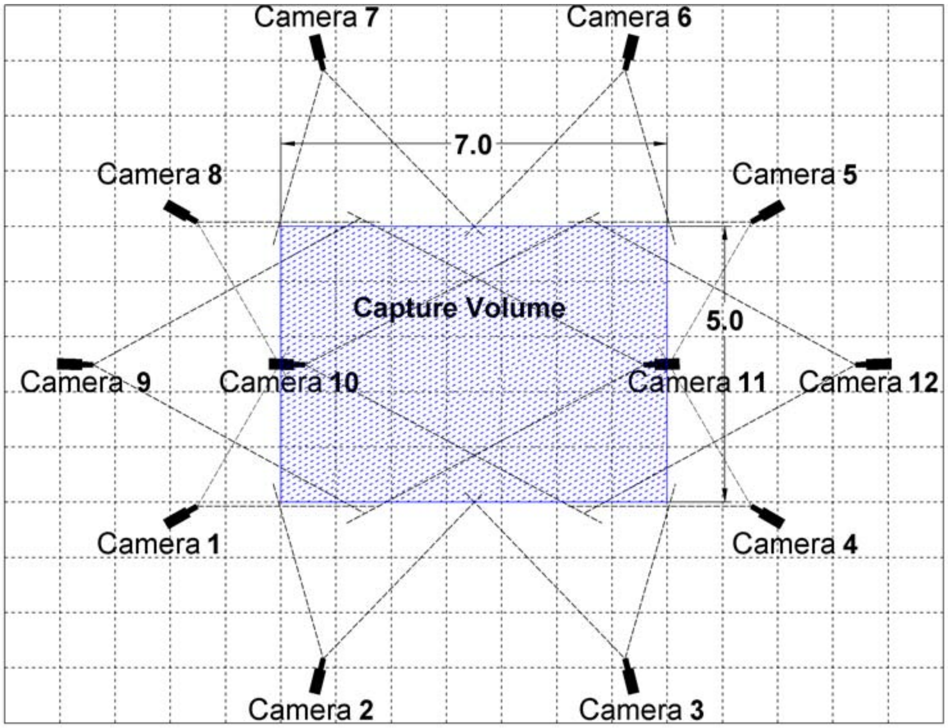

Camera 7
Camera 6
7.0
Camera 8
Camera 5
Capture Volume
5.0
Camera 9
Camera 10
Camera 11
Camera 12
Camera 1
Camera 4
Camera 2
Camera 3

Figure 5-7. Typical 14 Camera Setup

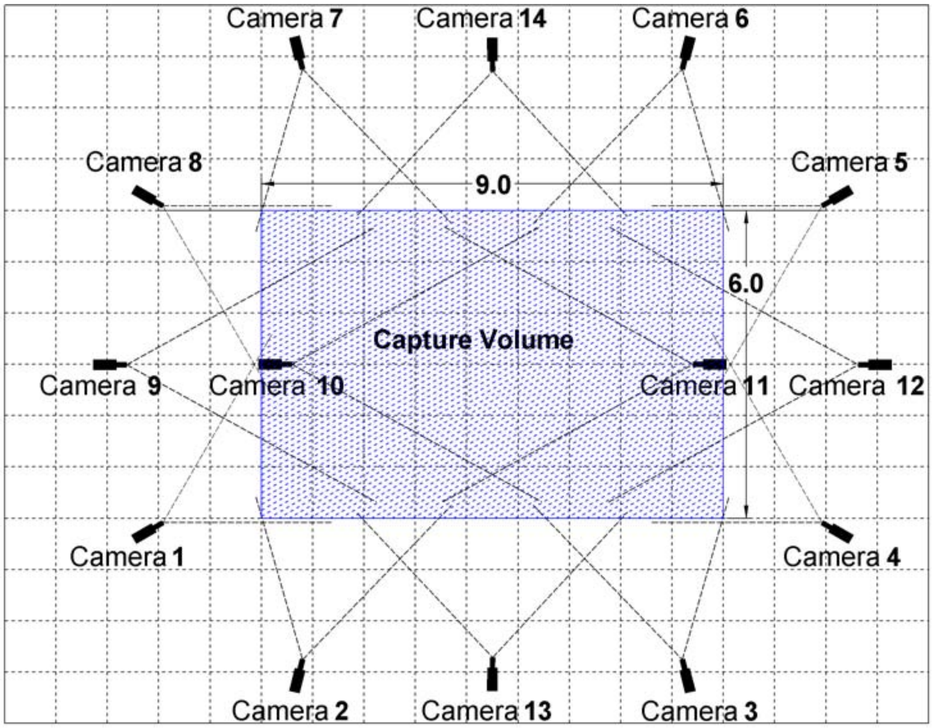

Camera 7
Camera 14
Camera 6
Camera 8
Camera 5
9.0
6.0
Capture Volume
Camera 9
Camera 10
Camera 11
Camera 12
Camera 1
Camera 4
Camera 2
Camera 13
Camera 3

Figure 5-8. Typical 16 Camera Setup

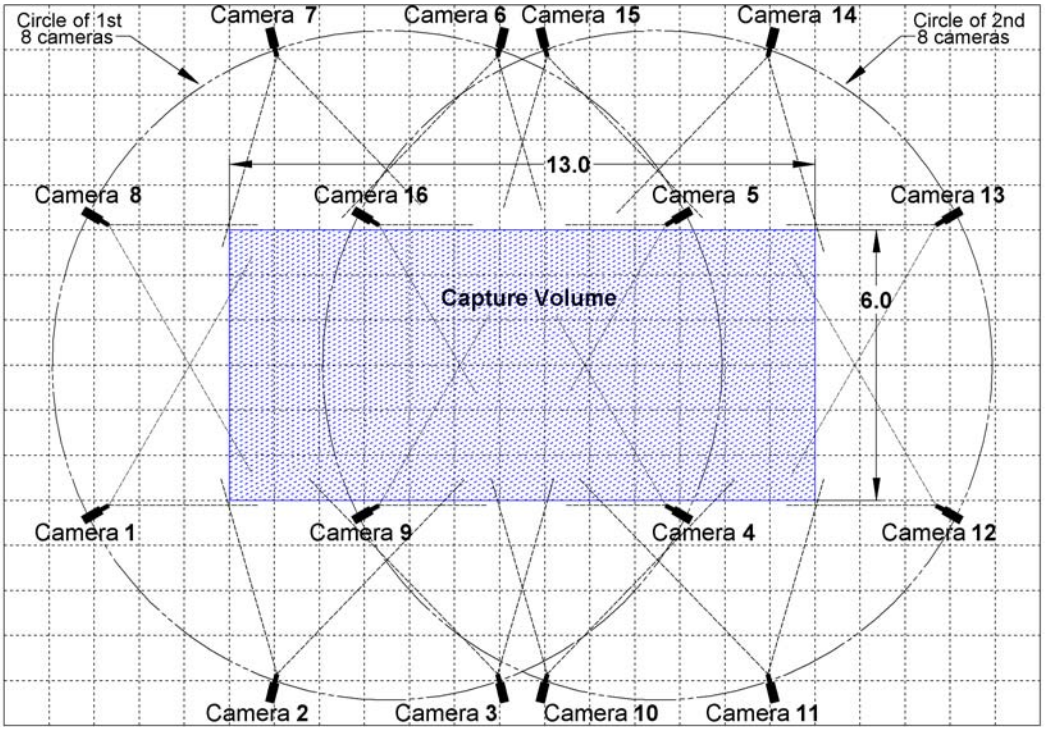
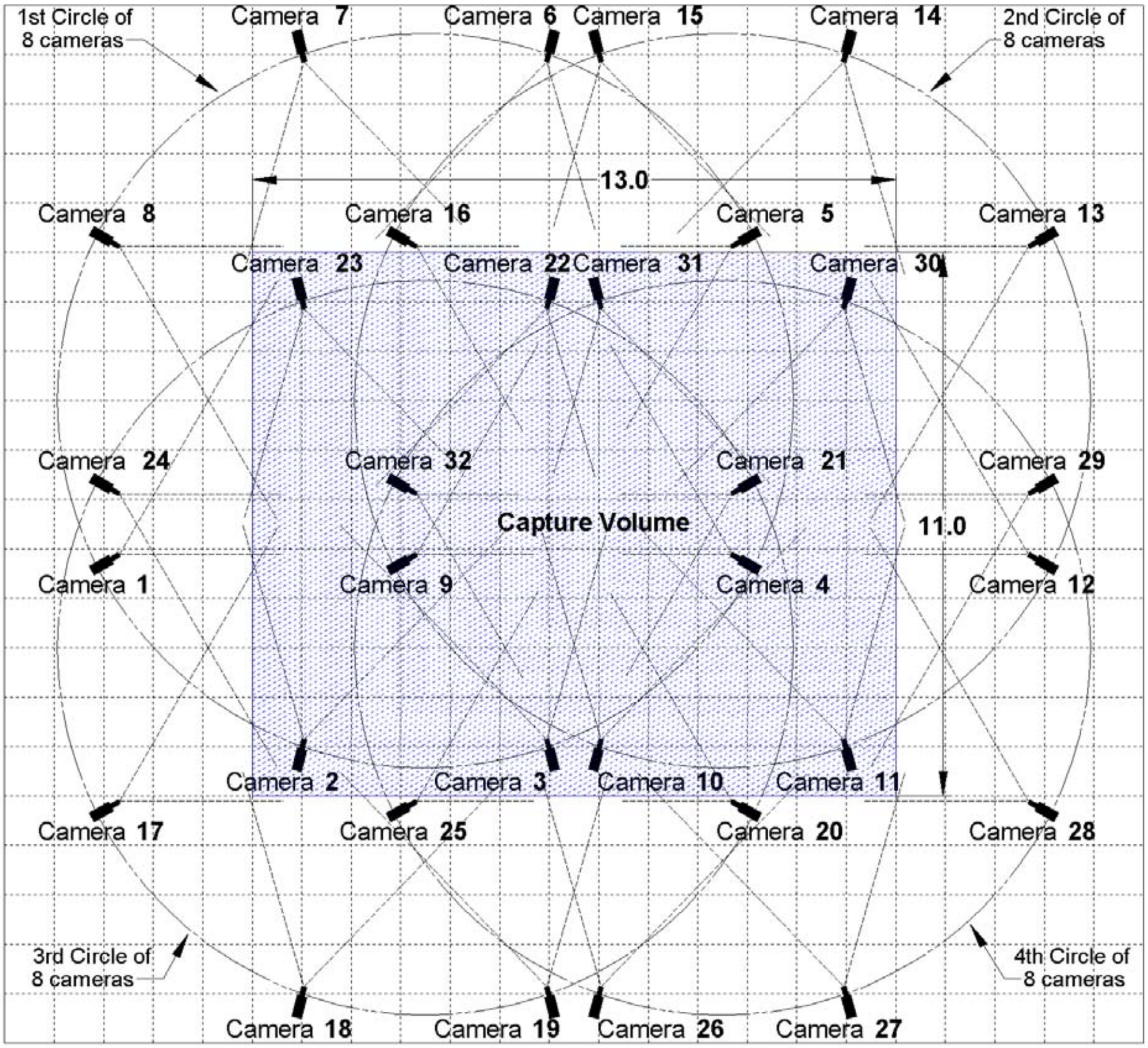

Circle of 1st
8 cameras
Camera 7
Camera 6
Camera 15
Camera 14
Circle of 2nd
8 cameras
13.0
Camera 8
Camera 16
Camera 5
Camera 13
Capture Volume
6.0
Camera 1
Camera 9
Camera 4
Camera 12
Camera 2
Camera 3
Camera 10
Camera 11

Figure 5-9. Typical 32 Camera Setup


1st Circle of 8 cameras
Camera 7
Camera 6
Camera 15
Camera 14
2nd Circle of 8 cameras
13.0
Camera 8
Camera 16
Camera 5
Camera 13
Camera 23
Camera 22
Camera 31
Camera 30
Camera 24
Camera 32
Camera 21
Camera 29
Capture Volume
11.0
Camera 1
Camera 9
Camera 4
Camera 12
Camera 2
Camera 3
Camera 10
Camera 11
Camera 17
Camera 25
Camera 20
Camera 28
3rd Circle of 8 cameras
4th Circle of 8 cameras
Camera 18
Camera 19
Camera 26
Camera 27

Note - The capture volume is divided into 4 overlapping regions, each containing 8 cameras. The regions are as follows:

Upper left quadrant	Cameras 1-8
Upper right quadrant	Cameras 9-16
Lower left quadrant	Cameras 17-24
Lower right quadrant	Cameras 25-32

Setting Up the Cameras

The key to placing cameras around the capture area is to position them where they will yield the highest resolution without excluding any part of the adjacent capture volume. In other words, if you plan to track 2 gait cycles, do not set up an area suitable for 4 gait cycles. When the tracking volume is increased, the quality and accuracy of the tracking data will decrease.

First, you will want to measure the room to establish the center of the tracking area.

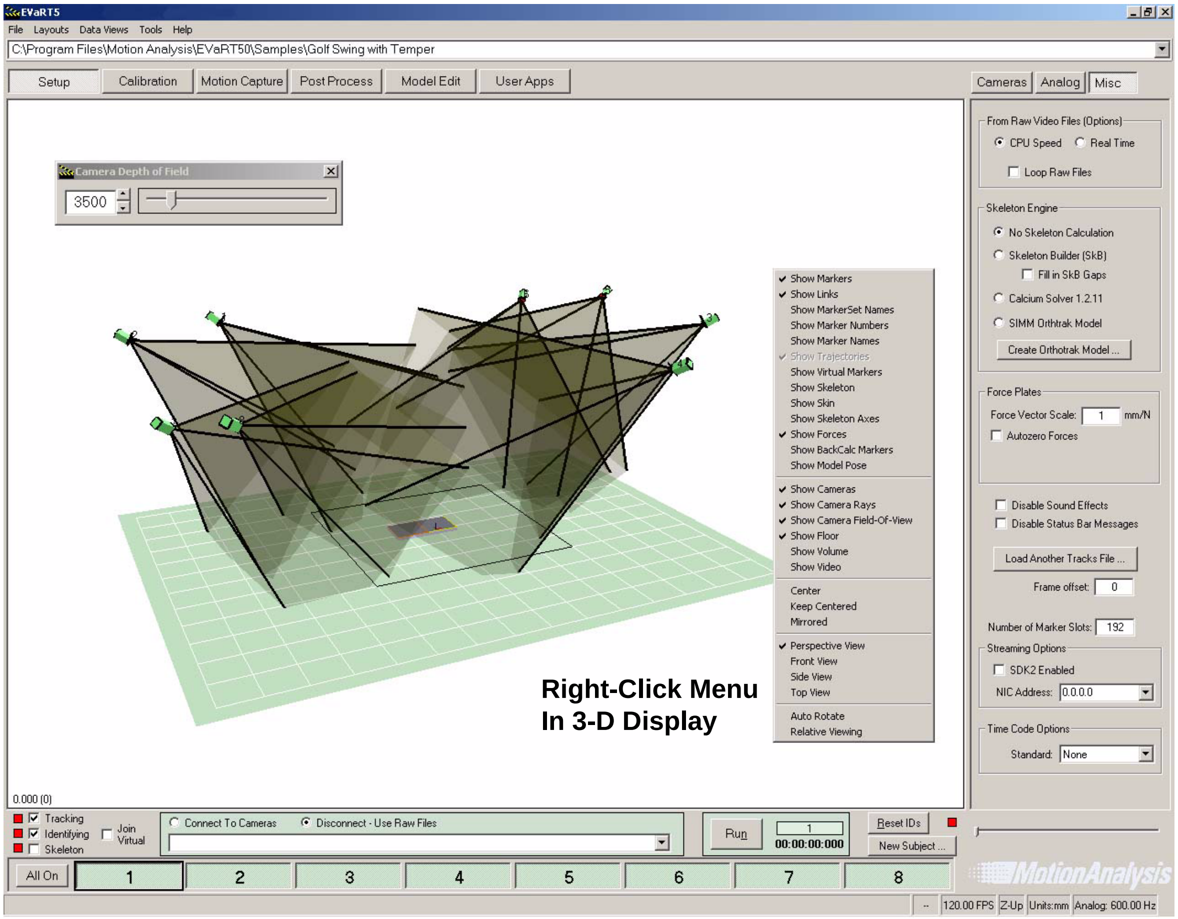
An Example Eagle or Hawk Camera Setup

For example, if you have a 10 x 15 meter room and you are using 8 Eagle or Hawk digital cameras:

1. Measure in from the walls 5 and 7.5 meters. This should be the center of a 10 x 15 meter room.
2. Mark the center of the room or tracking area with a piece of masking tape.
3. Find the corners of the actual capture volume. For optimum tracking, the length and width of the capture volume should be no more than about half the room dimensions.
4. Position the cameras evenly around the capture area. Place the cameras above the top of the capture space, looking down, to prevent cameras from seeing an opposing camera's ring light.
   - For most gait analysis installations, a height of 2 meters should be sufficient. For a larger capture area (e.g. full body or sports analysis), the cameras may need to be raised higher.
   - If a camera must view an opposing camera, use the mask function in **EVaRT** to block the offending image. Refer to "Creating and Clearing Masks" on page 7-9.
   - Position the cameras so that they are equally spaced when viewed from the center of the capture area.
   - Beware of making the capture area too large. The resolution and the quality of the data may be compromised.
5. Adding cameras low. Good results can come from adding cameras or positioning the cameras low (on the floor), looking up at the capture subject. This is also effective for capturing markers as the subject is stooped over or lying on the floor. Opposite camera ringlights can be masked out if necessary.

6. One by one, adjust each camera so it sees as much capture area as possible.
7. To see the camera view, right-click in the 3D display and then select **Show > Show Camera Field of View.** See Figure 5-10.

Figure 5-10. Show Camera Field of View

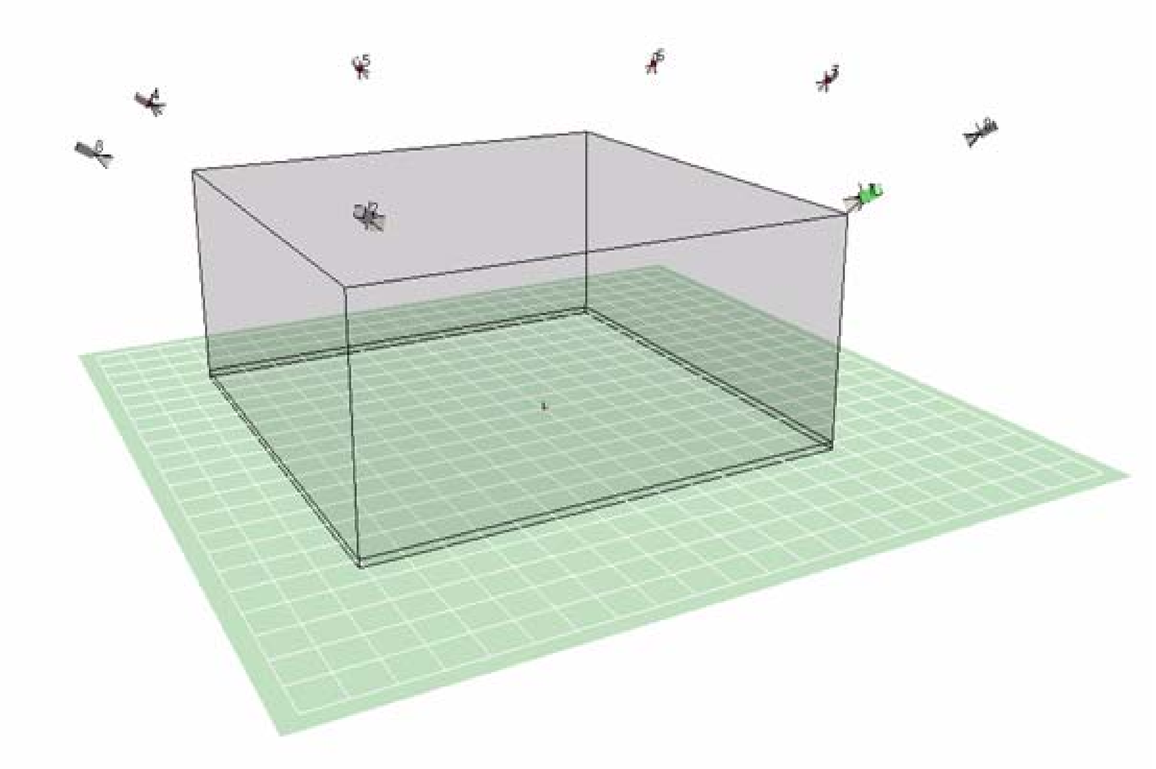

EVaRT5
File Layouts Data Views Tools Help
C:\Program Files\Motion Analysis\EVaRT50\Samples\Golf Swing with Temper
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Cameras
Analog
Misc
Camera Depth of Field
3500
Show Markers
Show Links
Show MarkerSet Names
Show Marker Numbers
Show Marker Names
Show Trajectories
Show Virtual Markers
Show Skeleton
Show Skin
Show Skeleton Axes
Show Forces
Show BackCalc Markers
Show Model Pose
Show Cameras
Show Camera Rays
Show Camera Field-Of-View
Show Floor
Show Volume
Show Video
Center
Keep Centered
Mirrored
Perspective View
Front View
Side View
Top View
Auto Rotate
Relative Viewing
From Raw Video Files (Options)
● CPU Speed ○ Real Time
☐ Loop Raw Files
Skeleton Engine
● No Skeleton Calculation
○ Skeleton Builder (SkB)
☐ Fill in SkB Gaps
○ Calcium Solver 1.2.11
○ SIMM Orthtrak Model
Create Orthotrak Model ...
Force Plates
Force Vector Scale: 1 mm/N
☐ Autozero Forces
☐ Disable Sound Effects
☐ Disable Status Bar Messages
Load Another Tracks File ...
Frame offset: 0
Number of Marker Slots: 192
Streaming Options
☐ SDK2 Enabled
NIC Address: 0.0.0.0
Time Code Options
Standard: None
0.000 (0)
☑ Tracking
☑ Identifying
☐ Skeleton
☐ Join Virtual
○ Connect To Cameras
● Disconnect - Use Raw Files
Run
1
00:00:00:000
Reset IDs
New Subject ...
All On
1
2
3
4
5
6
7
8
MotionAnalysis
120.00 FPS
Z-Up
Units:mm
Analog: 600.00 Hz

Right-Click Menu In 3-D Display

You can adjust the depth of the camera view by moving the slider in the Camera Depth of Field function (usually located in the upper-left corner of the interface when the Show Camera Field of View function is activated). This does not change the depth of view the camera will have. It only provides a visual aid to determine if an object at a particular distance will be in the camera's field of view.

8. To see the capture volume, right-click in the 3D display and select **Show Volume**.

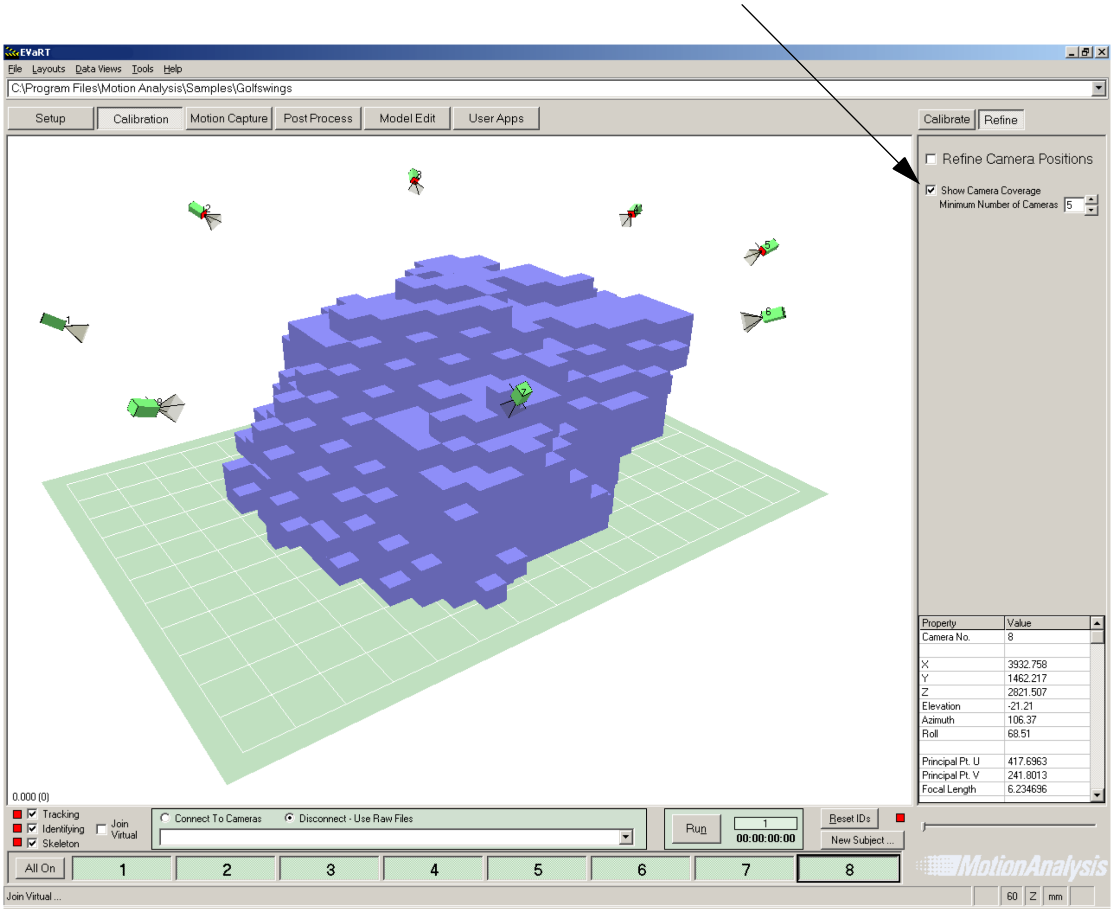
Figure 5-11. Show Volume



9. To See the camera coverage in the volume, select the **Show Camera Coverage** check box in the **Calibration > Refine** sub-panel, and then right-click in the 3D view and select **Show Volume**. Select Show Field of View again to turn the camera rays off. See Figure 5-12.

Figure 5-12. Show Camera Coverage

Show Camera Coverage


EVaRT
File Layouts Data Views Tools Help
C:\Program Files\Motion Analysis\Samples\Golfswings
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Calibrate
Refine
1
2
3
4
5
6
7
8
0.000 (0)
Reset IDs
New Subject ...
All On
1
2
3
4
5
6
7
8
MotionAnalysis
Join Virtual ...
60
Z
mm

☐ Refine Camera Positions

☑ Show Camera Coverage

Minimum Number of Cameras 5

Property	Value
Camera No.	8
X	3932.758
Y	1462.217
Z	2821.507
Elevation	-21.21
Azimuth	106.37
Roll	68.51
Principal Pt. U	417.6963
Principal Pt. V	241.8013
Focal Length	6.234696

☑ Tracking
☑ Identifying
☑ Skeleton
☐ Join Virtual

○ Connect To Cameras ● Disconnect - Use Raw Files

Run 1 00:00:00:00

10. For the example capture area of 5 by 7 meters, 2 meters high, most Eagle and Hawk camera lenses can be set to a focus of 00 (infinity) and an f-stop that is wide-open (smallest number).
11. Set the shutter speed in the **EVaRT** software so the markers are bright and have a good threshold setting (usually about 500).
12. Place the Calibration Square in the center of the taped area. A useful convention is to place marker #1 on the square closest to camera #1.

Note: The cameras need at least 20 minutes to warm up before collecting calibration or trial data.

Tracking With More Than 8 Cameras

As the subject moves from one region to the next in a multiple region capture volume, **EVaRT** has no problem as the subject leaves the view of some cameras while entering the view of others. The only requirement is that at least two (preferably three or four) cameras can see the subject at all times.

For additional cameras to be effective, they must be sufficiently far apart so that the rays from a given marker to the two adjacent cameras subtend a large enough angle to yield good positioning data.

Using Many Cameras in a Small Volume

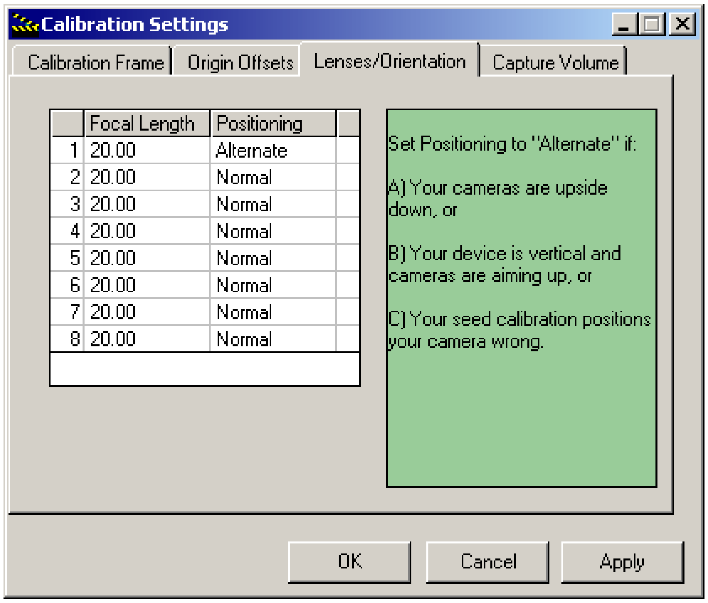
It is possible to use eight or more cameras effectively in a relatively small volume if there is sufficient height. We suggest placing half the cameras at a moderate height and the other half as high as possible. You may need to experiment to obtain the optimum camera adjustment for your lab or studio.

Adjusting Camera View for Increasing Height

If your capture volume is too high for your Eagle or Hawk cameras, you may turn the cameras on their side (just as photographer may turn their camera on its side for increased height). Note that your camera width coverage will decrease. You may turn the cameras on their side, up to 89° without having to make any changes to the software settings. If you turn the camera 90° or greater, you will need to select the Alternate setting for the particular camera(s). This is done in the **Calibration > Calibrate** subpanel. Select **Details > Lenses/Orientation**, then change the setting from **Normal** to **Alternate**. If the camera is hanging upside-down, you will need to use the Alternate position.

Note: Do not leave the cameras set too close to 90° (i.e. 85° to 95°) since it may appear Normal or Alternate and result in non-repeatable calibrations.

Figure 5-13. Lenses/Orientation Window



	Focal Length	Positioning
1	20.00	Alternate
2	20.00	Normal
3	20.00	Normal
4	20.00	Normal
5	20.00	Normal
6	20.00	Normal
7	20.00	Normal
8	20.00	Normal

Set Positioning to "Alternate" if:

A) Your cameras are upside down, or

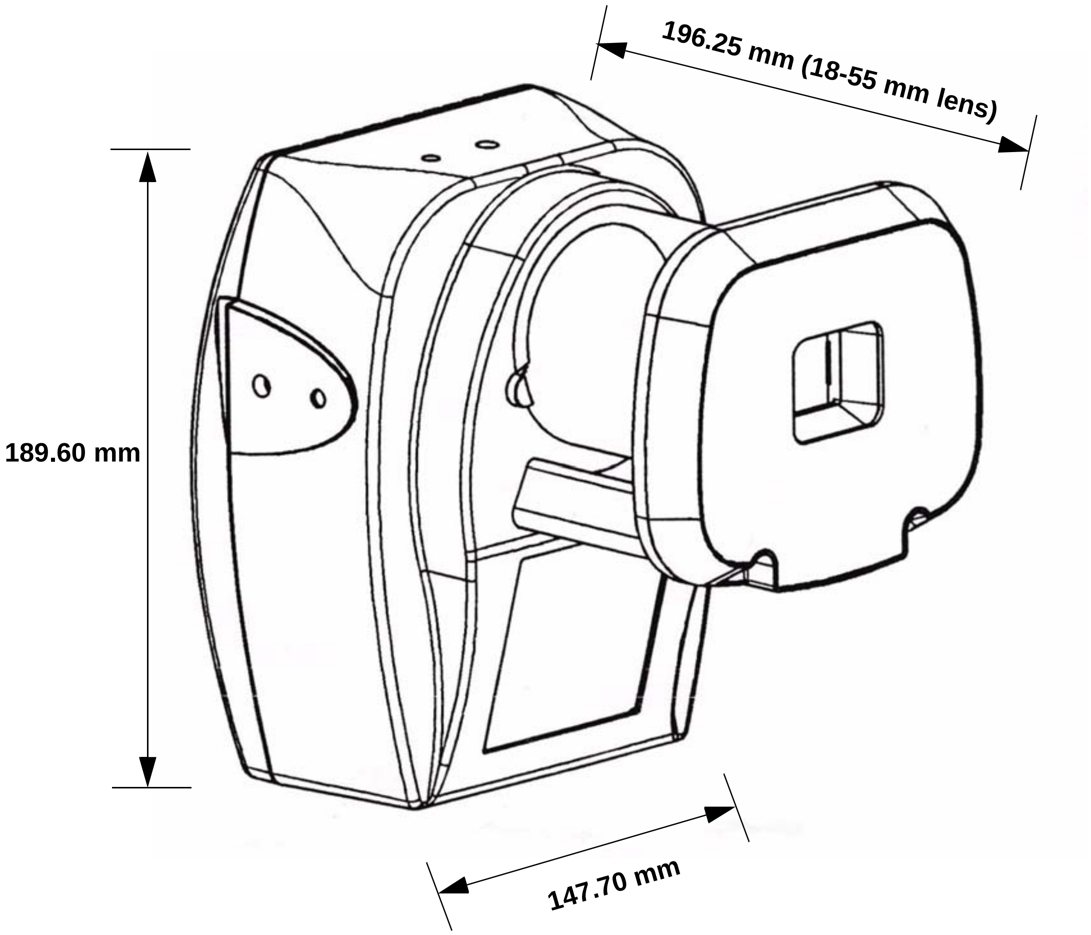
B) Your device is vertical and cameras are aiming up, or

C) Your seed calibration positions your camera wrong.

Eagle Camera Physical Dimensions

The following diagram illustrates the physical size and weight of the Eagle digital camera. The tripod mounting points are the holes used to hold the tripod bolt. There are four tripod mounting points on each camera.

Figure 5-14. Eagle Camera Physical Dimensions

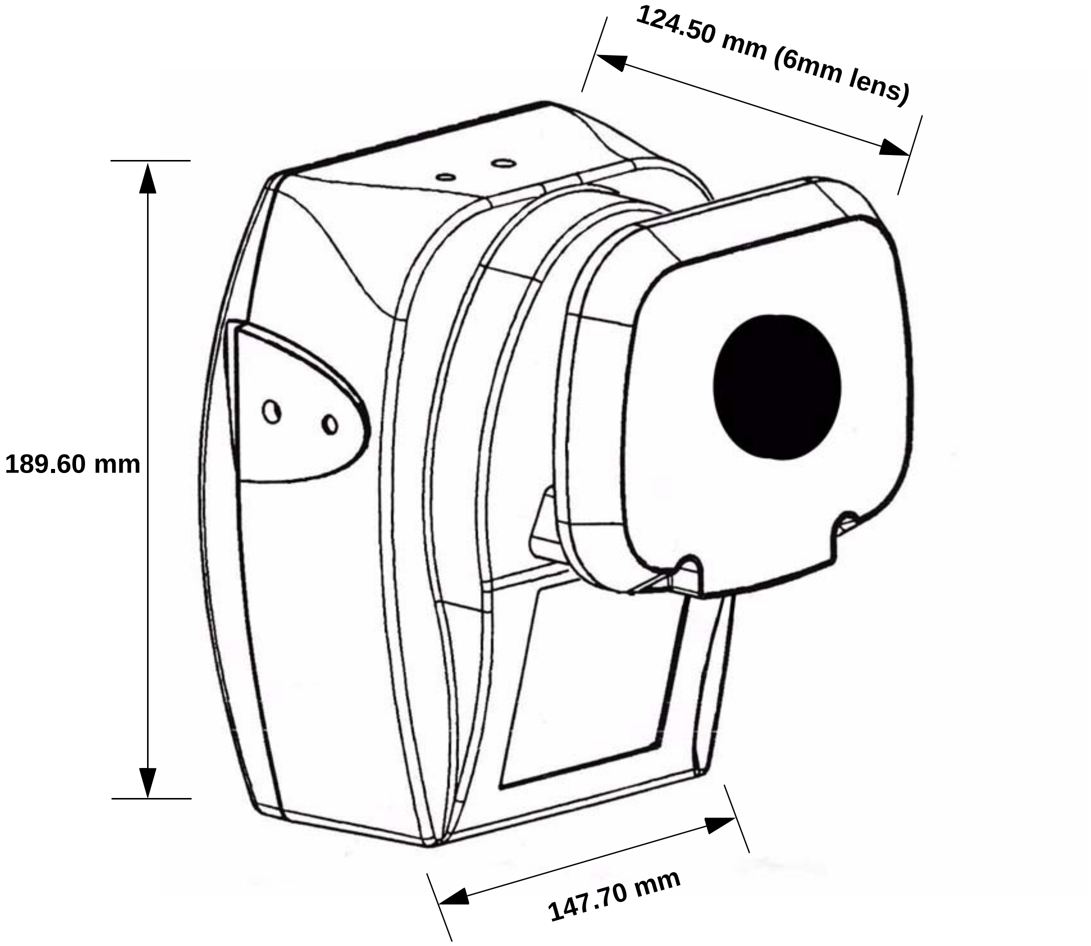


Tripod Mounting Points = 1/4 in. diameter x 20 threads/inch
Camera Weight = 2.2 kg with lens (4.9 lbs.)

Hawk Camera Physical Dimensions

The following diagram illustrates the physical size and weight of the Hawk digital camera. The tripod mounting points are the holes used to hold the tripod bolt. There are four tripod mounting points on each camera.

Figure 5-15. Hawk Camera Physical Dimensions

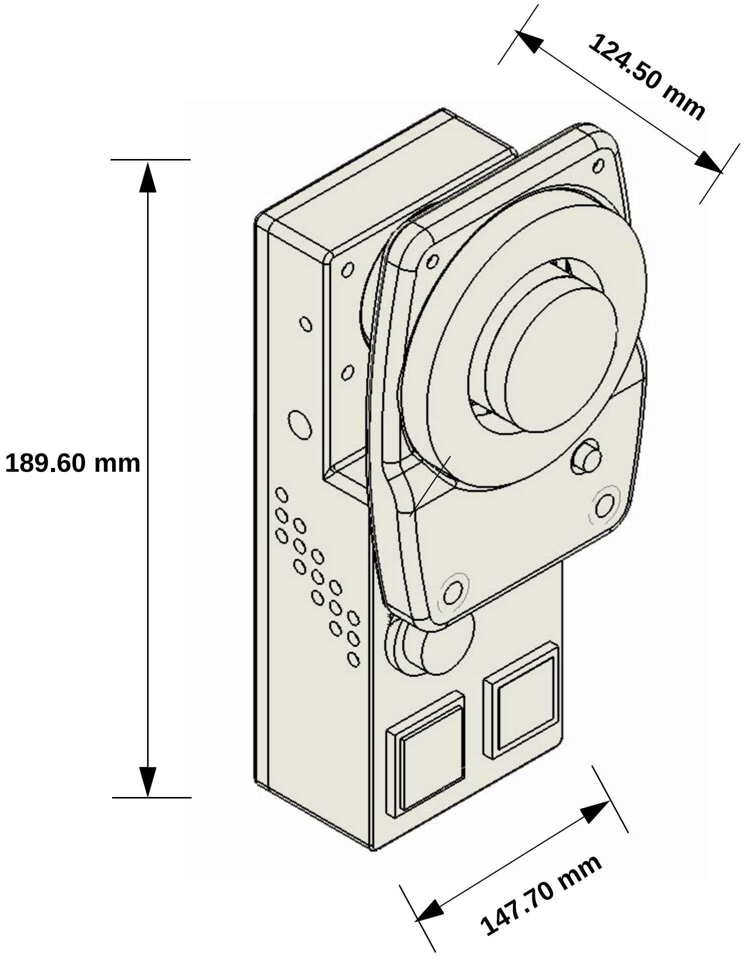


Tripod Mounting Points = 1/4 in. diameter x 20 threads/inch
Camera Weight = 2.1 kg with lens (4.7 lbs.)

Hawk-i Camera Physical Dimensions

The following diagram illustrates the physical size and weight of the Hawk-i digital camera. The tripod mounting points are the holes used to hold the tripod bolt. There is one tripod mounting point on each Hawk-i camera.

Figure 5-16. Hawk-i Camera Physical Dimensions



Tripod Mounting Points = 1/4 in. diameter x 20 threads/inch
Camera Weight = 2.1 kg with lens (4.7 lbs.)

Overview of the System Calibrating Process

Three-dimensional tracking is performed in two stages: a seed and a wand calibration. A relationship must be established between real-world positions (object-coordinates) and the corresponding image-coordinates from the camera view. This is called calibrating the system. When a target is visible in two or more camera views, there is sufficient information available to track the targets in three-dimensional space.

The calibration of a given camera’s view is completely dependent on the camera lens focal length and the position and orientation of the camera with respect to an arbitrary reference frame called the object-reference-frame. A change of any sort, which alters the relationship between the object-coordinates and image-coordinates, must be followed by a fresh calibration. This includes accidently bumping a camera tripod.

The calibration process calculates eleven calibration coefficients which implicitly define the configuration of a particular view. The calibration coefficients, together with the image-coordinates of a single target, are sufficient to define the path of an optical ray from the target to the camera through the object-space. If rays from two cameras intersect in space at a specific time, they define the 3D position of a target at that time. Therefore, the tracking process is one of intersecting optical rays generated from different views of the same event. **EVaRT** employs a “best fit” tracking algorithm using only good camera views.

The Calibration Coordinate System

In order to calibrate the system, you must first decide on the location of the origin and orientation of your object-reference-frame. This is determined by the Calibration Square. All results generated by the tracking process are referred back to this reference frame.

The selection of an object-reference-frame is arbitrary. However, judicious selection is advised. In most cases, it is advisable to align one axis of the frame with the axis of gravity and another with the predominant direction of motion. Remember, that all targets will be tracked with respect to the object-reference-frame, and that the units used to locate the control points (mm, cm, inches, etc.) will be the same units used in the tracking process.

For computer animation users, a commonly used coordinate system convention is called “Y-up”, with the Y axis pointing up, the +Z axis normal to the direction of motion and the +X axis oriented from the person’s right side to left side. Looking at the frontal view, you would see a normal X-Y plot (Y-up, X-right) and the +Z coordinate sticks out of the screen.

For biomechanics applications, it is common to use a coordinate system with +Z up, +X in the direction of forward motion, and +Y toward the subject’s left side.

The coordinate convention you use is your choice. Be sure that:

- The coordinates of the calibration square are entered into your project file(s) correctly.

- The Calibration Square is oriented correctly in the room when you collect the calibration trial. The position of the Calibration Square determines the orientation of your calibration.

Note: The International Society of Biomechanics (ISB) has officially adopted the convention that the Y axis should point up. This has the advantage that in both 2D and 3D studies, the Y axis is up. However, many studies and software packages use the Z-up coordinate system favored by mathematicians.

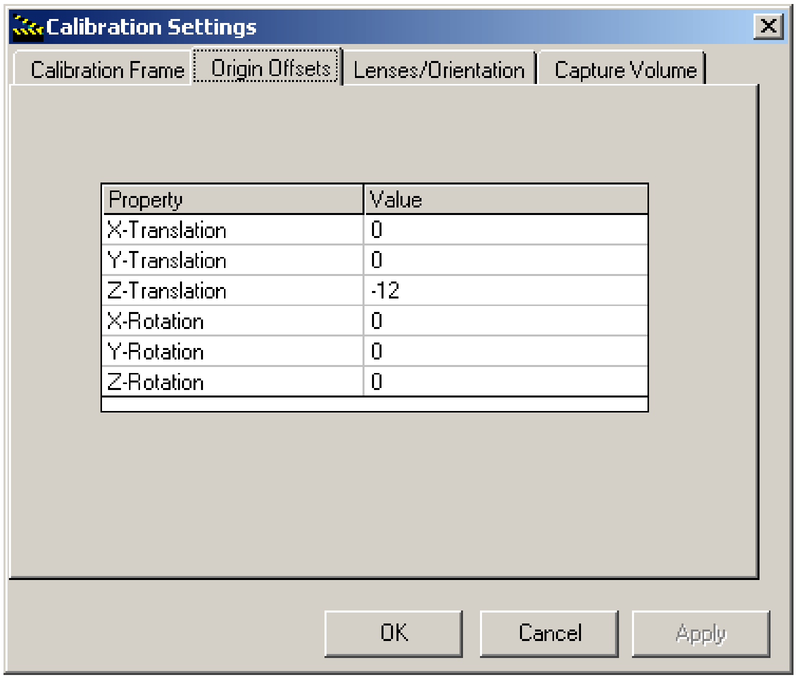
Control Points

Once a reference frame has been selected, you must provide a number of calibration markers with known locations, which can be used for control purposes; hence, these calibration markers are known as control points. The control points serve much the same purpose as the simple scale widely used for two-dimensional studies—they are, in fact, a three-dimensional yardstick representing the X, Y, and Z dimensions.

Motion Analysis offers a calibration square with four retro-reflective spheres. The relative position of the spheres have been accurately measured.

Place the calibration square at the origin (or at an accurately measured point) of the laboratory's test area. When placing the calibration square, consider the direction of motion to be studied, position of force plates, etc. You can change the orientation of the calibration square by making adjustments to the Origin Offsets table. This is located in the **Calibration > Details > Calibration Settings Origin Offsets** tab. Refer to Figure 5-17.

Figure 5-17. Calibration > Details > Calibration Settings Origin Offsets



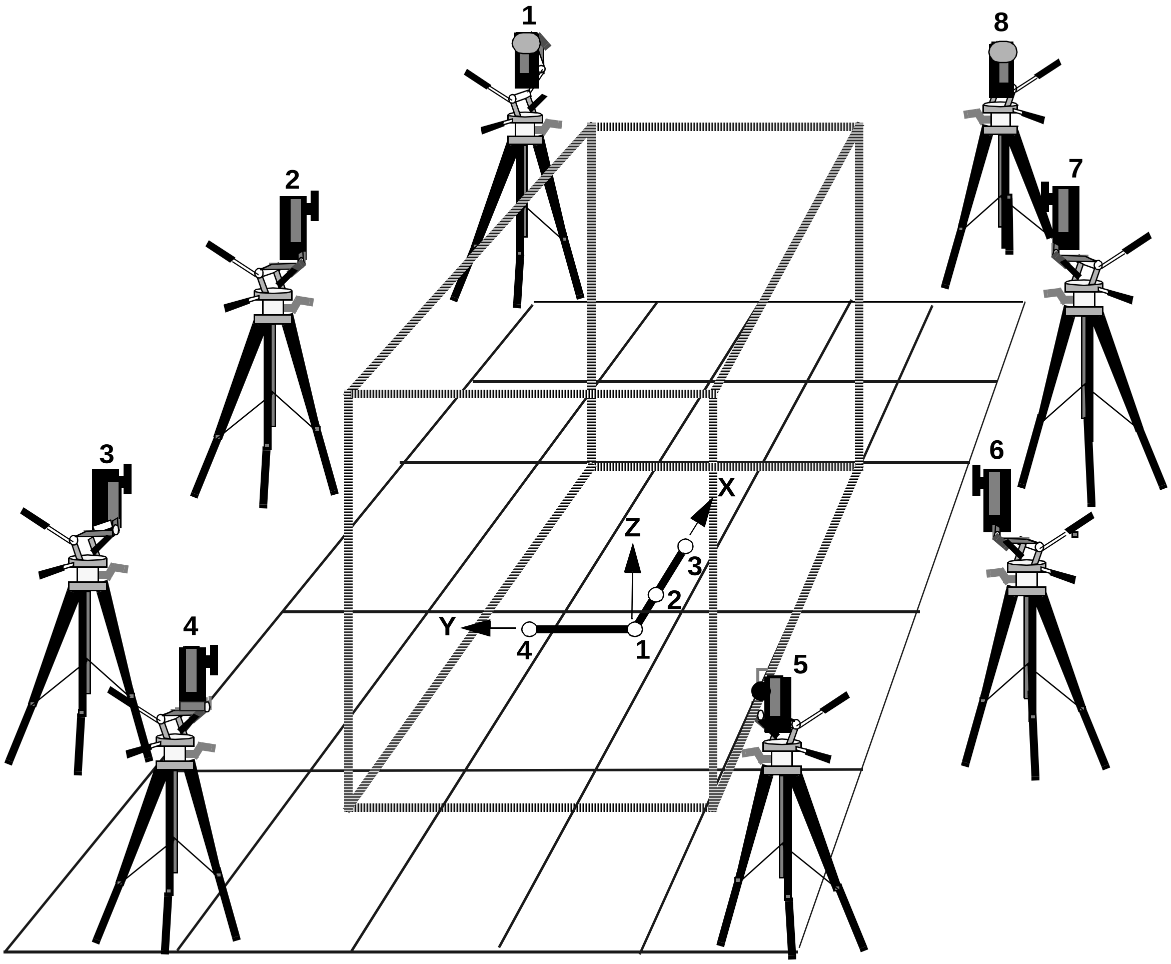
Property	Value
X-Translation	0
Y-Translation	0
Z-Translation	-12
X-Rotation	0
Y-Rotation	0
Z-Rotation	0

Placing the Calibration Square

Mark the floor area with tape where the motion is to take place.

- Set Marker #1 of the Calibration Square at the desired origin of the capture volume.
- If the orientation of the coordinate system is not important, the square should be rotated so as many control points as possible can be seen by all cameras.
- Check the video monitor to see if any of the four points on the Calibration Square are merging. The Calibration Square should be seen by at least half of the cameras to give a good calibration. The other half of the cameras can be calibrated using the wand, with an Extend Seed menu item. You may need to adjust the cameras at this point.

Figure 5-18. Placing the Calibration Square In the Capture Volume (Z-Up)



Marker Sizes and Maximum Distances for Eagle/Hawk Cameras

The limiting factor in what size marker works in what volume is the distance the marker is viewable (and usable) from the camera.

"Min 3 lines" below is the minimum number of scan lines (or pixels) to allow in calculating a 2D centroid. As a rule, the more lines, the cleaner the 2D data and resulting 3D data. But once you get above 3 lines, the data is very clean and going more lines per centroid does not generally make the data any better.

Table 5-2. Marker Size and Maximum Distance for Eagle Digital Cameras

Eagle Camera Marker Size	Distance (m)	
	Min 3 Lines	Min 2 Lines
6 mm (1/4 in.)	4.2 m	7.0 m
12 mm (1/2 in.)	8.0 m	12.0 m
19 mm (3/4 in.)	10.7 m	15.0 m
25 mm (1 in.)	12.1 m	16.0 m

These are empirical tests taken from an Eagle camera with the 20-35 mm zoom lens, at a capture rate of 60 Hz, 100% brightness, and a threshold = 500.

Note: Hawk cameras will require markers that are approximately 50 to 100% larger than those listed in Table 5-2.

When using 1/2-inch markers, the useful distance for VERY CLEAN data (Min. 3 lines per centroid) is about 8 meters. Going to a minimum of 2 lines per centroid, takes the usable distance to 12 meters. Going to the 3/4 inch marker gains another 3 meters (to 15 meters). A note of interest is that going to a one-inch marker does not give a big boost in distance. Other factors come into play, such as the inverse square law about light falling off as we get further from the source. Above 16 meters, the markers are "self extinguishing".

Our experience indicates that if you go beyond about 10 meters in any direction of the capture volume (length or width), it is best to have a second tier of cameras in the middle of the longer dimension. This is a big benefit for multiple person captures as it minimizes editing time needed since you get lots of good solid 3D marker points.

Troubleshooting Eagle and Hawk Camera Problems

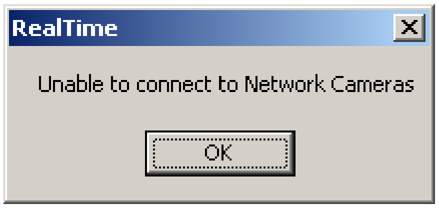
If Any Cameras Fail to Respond

Motion Analysis sets the default network address in the software to 10.1.1.199. Please note, some computers have multiple network cards installed in them. Please make sure they are labeled so there is no confusion.

If you or your IT department has changed the network address for your system or your cameras, please make note of this for reference as it will save you time in the future.

If you see the error shown in Figure 5-19, there can be multiple reasons why.

Figure 5-19. Unable to Connect to Cameras Error

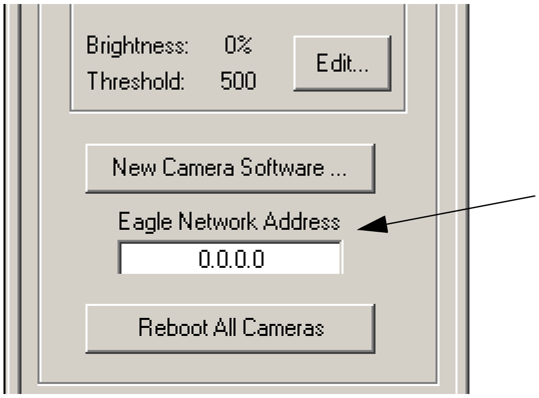


Unable to connect to Network Cameras

The following are some steps to try and fix the problem, starting with the simplest and progressing to the more complex.

1. Under the **Setup > Cameras** subpanel, verify the Eagle Network Address in the Eagle Network Address box.

Figure 5-20. Eagle Network Address Box



Brightness: 0%
Threshold: 500

Eagle Network Address
0.0.0.0

If nothing has been changed this should have a network address of 10.1.1.199. Try and connect to cameras again. If this does not fix the issue please move on to the next step.

2. Make sure that the Network cable going from the back of the computer to the EagleHub is securely installed. Motion Analysis uses the on-board network port for the Eagle Network. If you purchased a computer from another source, this may not be how your system is setup. Please take note of this when checking the connections, as it will be useful when talking to Motion Analysis Customer Support staff.
   - **a.** Unplug the network cable from the back of the computer and plug it back in.
   - **b.** Do the same for the connectors on the EagleHub. You should hear an audible "Click" when inserting it back into the jack.
3. If Windows Updates has been recently run (they may be running in the back ground), there may be a possibility that the Microsoft Windows Firewall was either installed or turned on. This will need to be turned off, as well as any other Firewall software installed on your motion capture computer. Because of the nature of the digital cameras, it is required that the network coming in to the computer, on a particular IP address, is open for streaming data. If your facility requires a Firewall to be installed for their network, it will need to be configured to leave the Eagle Network untouched and open.

   You can turn off the Windows Firewall by going to the **Start > Settings** menu in your Windows desktop and then selecting **Control Panel > Security Center**. This is a feature in Windows XP, Service Pack 2 and later software.

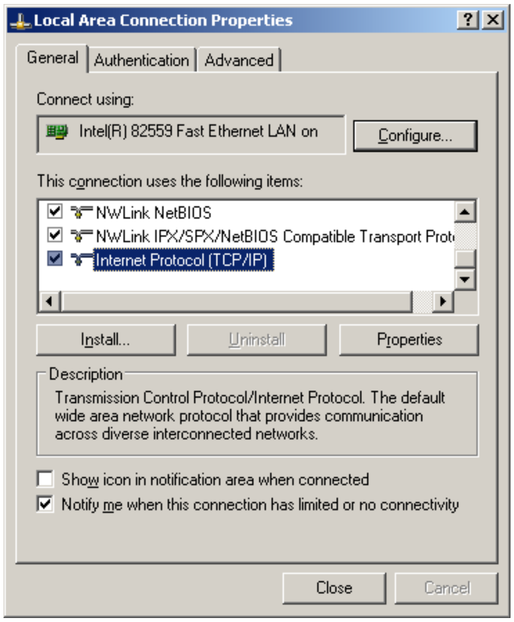
4. Double-check to make sure the Network Address that is set in **EVaRT** is the same as the Network Address that is assigned to your Network Interface Card (NIC). To do this follows these steps:

  a. From your desktop, select **Start > Settings > Control Panel > Network Connections**. You should have a "Local Area Connection" and possibly an "Eagle On-board Network" (or Hawk if so stated). There may also be "1394 IEEE Connection", this is for Fire Wire and can be ignored.

  b. Right-click the appropriate network connection for the Eagle Network and select **Properties** from the drop down menu.

  c. Under the General tab, scroll down and select **Internet Protocol (TCP/IP)** and click on the **Properties** button.

Figure 5-21. Internet Protocol (TCP/IP) Properties Selection



Connect using:
Intel(R) 82559 Fast Ethernet LAN on

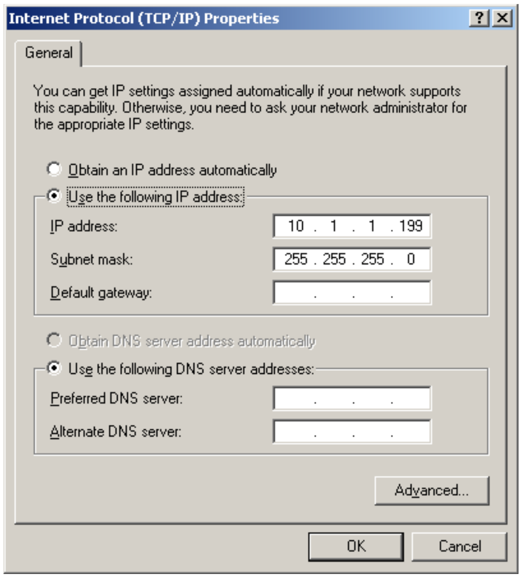
This connection uses the following items:
☑ NWLink NetBIOS
☑ NWLink IPX/SPX/NetBIOS Compatible Transport Prot
☑ Internet Protocol (TCP/IP)

Description
Transmission Control Protocol/Internet Protocol. The default wide area network protocol that provides communication across diverse interconnected networks.

☐ Show icon in notification area when connected
☑ Notify me when this connection has limited or no connectivity

d. You should have “Use the following IP address” selected, if not, please make sure you have selected the proper network connection. You may close this window and return to Step 4b. The IP Address should be 10.1.1.199 and the Subnet Mask should be 255.255.255.0. If either of these is incorrect, please change them.

Figure 5-22. IP Address and Subnet Mask Address



Internet Protocol (TCP/IP) Properties

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically

● Use the following IP address:

IP address: 10 . 1 . 1 . 199

Subnet mask: 255 . 255 . 255 . 0

Default gateway: . . .

○ Obtain DNS server address automatically

● Use the following DNS server addresses:

Preferred DNS server: . . .

Alternate DNS server: . . .

5. If the software has still not connected to the Camera Network, use the DOS interface in Windows to Ping the cameras to verify if there isn’t a hardware failure.

  a. To Ping a camera, select **Start > Run** from the Windows desktop. In the pop up window, type in **`cmd`**. This will launch the command prompt.

  b. Type in `Ping 10.1.1.201` and press **Enter**. If the request times out (it will try 4 times) try doing the next number, 10.1.1.202 and so on. Your cameras should be set to 10.1.1.201 for camera number 1 and 10.1.1.202 for camera number 2 and so on (unless changed by you or your IT personnel). If the cameras do not respond then you may need to use your Eagle Test Cable to determine the Camera Network address. The Eagle Test cable is the black cable about 1 meter in length, one end plugs into the Aux port on the back of the camera, the other end has a VGA port, a COMM port and a BNC connector. Follow the steps found in Appendix A-23 through A-24; this will display the Network address of your camera.

The Ping command should return a message similar (but not exactly the same) as follows

:

```
Pinging 10.1.1.201 with 32 bytes of data:

Reply from 10.1.1.201: bytes=32 time=20ms TTL=128
Reply from 10.1.1.201: bytes=32 time=20ms TTL=128
Reply from 10.1.1.201: bytes=32 time=20ms TTL=128
Reply from 10.1.1.201: bytes=32 time=20ms TTL=128

Ping Statistics for 10.1.1.201:
          Packets: Sent=4, Received: 4, Lost=0 (0% loss),
Approximate Round trip times in milliseconds:
         Minimum=0ms, Maximum=242ms, Average= 128ms
```

If you are getting a message that says:

```
Pinging 10.1.1.201 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping Statistics for 10.1.1.201:
          Packets: Sent=4, Received: 0, Lost=4 (100%
loss),
Approximate Round trip times in milliseconds:
         Minimum=0ms, Maximum=0ms, Average= 0ms
```

Then the camera is not responding to Ping requests.

6. This last step involves trying to determine if there is a camera, cable, or connection that may be causing the system to not identify the cameras. The best way to do this is to unplug all of the cameras from the EagleHub. Then, plug each camera in, by individually (do not connect any other camera cables to the hub). It does not matter which RJ45 port you connect the camera network cable. The same applies to the power connector. The only other connection going into the EagleHub is the cable coming from the back of the Host computer (**EVaRT** tracking computer).

After you have plugged-in a camera, click-on the **Connect to Cameras** button on the Real-Time Dashboard. If this works, unplug this camera and set it off to the side or label it as good. Move on to the next camera doing the same, and so on, each time remembering that there should only be one camera plugged into the EagleHub at a time. This will help you narrow down if there is a conflict.

After running through each individual camera, it is very useful to power down the EagleHub to help clear out any stored data that may be in its memory. You may also want to take the time to write down IP address for each camera. If you run into a problem with multiple IP

Addresses being the same, this could be the problem. Each camera needs to have it's own independent IP Address. No two addresses can be the same. This makes each camera unique and will help the system identify them.

Socket Error

When connecting to the cameras on the RealTime Dashboard, if you encounter a SOCKET ERROR, you will need to verify the following:

- that the Ethernet connector on the back of the Host Computer is working properly.
- that the Ethernet cable running from the EagleHub (or switch connected to multiple EagleHubs) to the EVaRT Host Computer is connected.

Function Not Found In Library Error

If you get the message `ERROR: Function not found in library`, you have an older version of a library that is not working or is needed. If you do not have the A-D option, check the **C:\Winnt\System32** directory and rename the file **nidaq32.dll** to be **nidaq32.dll.old**. Then close and relaunch **EVaRT.** This applies for Windows 2000 operating system. If you are using a different operating system, you will need to do a search for the file **nidaq32.dll**.

Relationship Between Capture Volume and Marker Size

Note: The following is for Midas-based cameras only (i.e. Falcon, Cohu, Pulnix, etc.). Eagle and Hawk cameras set marker size parameters through the **EVaRT** interface.

Listed in Figure 5-23 are Optimal (Highest Accuracy), Large Volume, and Extended Volume capture areas for the 6, 8, and 10 Falcon camera systems. Larger volumes require more cameras. Different shaped capture areas are also possible.

At the extremes, volumes will vary with ceiling heights and can vary with optical conditions including external lighting.

Figure 5-23. Guidelines for Selecting Marker Size for Falcon Cameras

		Normal Capture Volume	
	Marker Size	**meters**	**# Cameras**
Highest Accuracy	Eagle = 3/8-inch (9mm)	2.5 x 2.5	6
	Hawk = 1/2-inch (12.5mm)	2.5 x 3.5	8
	Falcon = 3/4-inch (19mm)	2.5 x 5	10
Large Volume	Eagle = 1/2-inch (12.5mm)	3.5 x 3.5	6
	Hawk = 3/4-inch (19mm)	3.5 x 6	8
	Falcon = 1-inch (25mm)	3.5 x 8	10
Extended Volume	Eagle = 3/4-inch (9mm)	5 x 5	6
	Hawk = 1-inch (12.5mm)	5 x 8	8
	Falcon = 1 1/2-inch (19mm)	5 x 11	10
1/8" and 1/4" markers are also available for smaller volumes such as face, hand, or foot capture volumes.			

Chapter 6

The EVaRT User Interface

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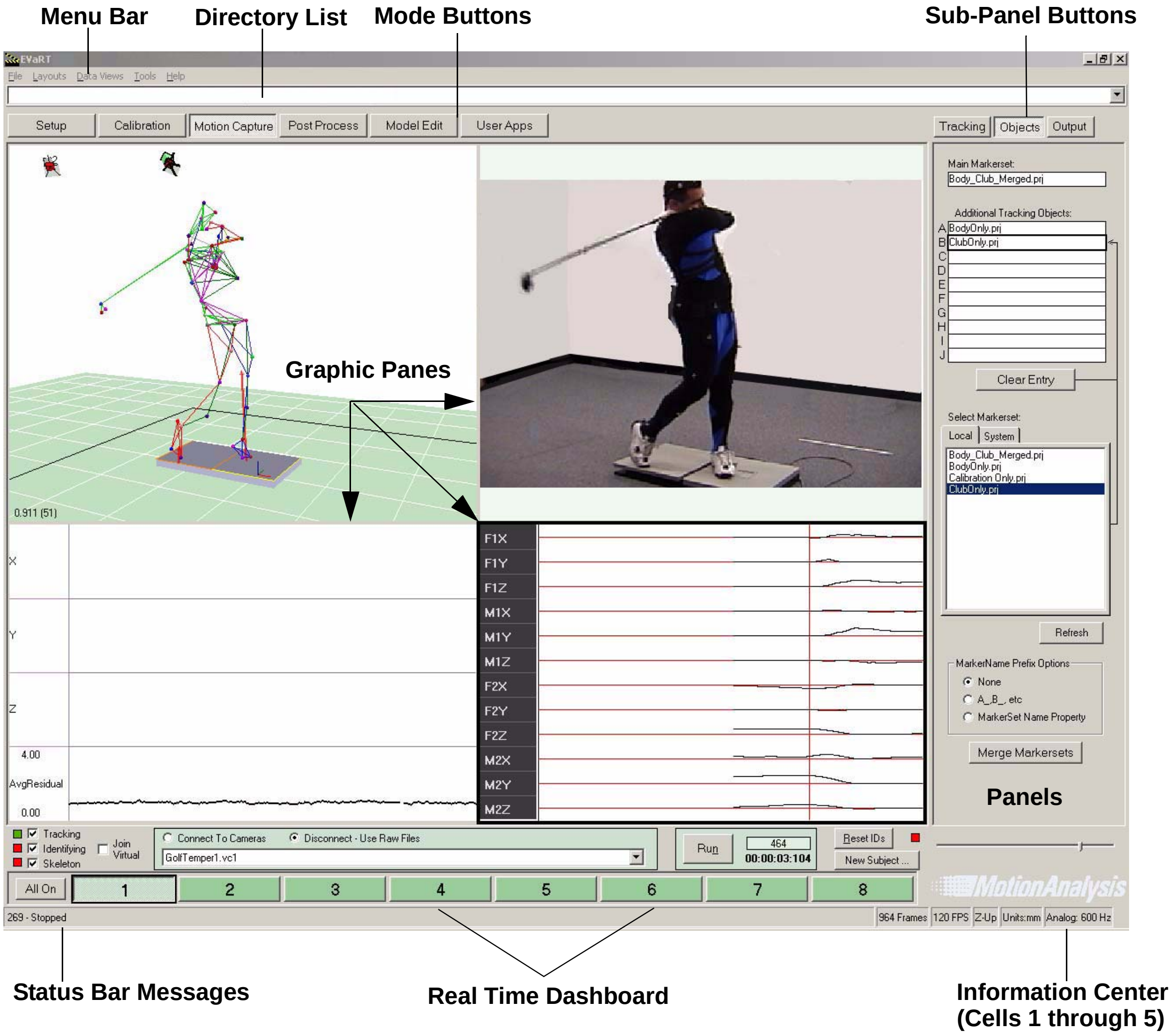
Getting Acquainted With the User Interface

Before using **EVaRT** it is necessary to become familiar with the interface and the names of the tools and controls that will be used throughout this manual. The major components are as follows:

1. The Graphics Panes in the center of the screen.
2. The Menu Bar in the upper left corner.
3. The Directory List below the Menu Bar.
4. The Mode Buttons along the top left of the screen.
5. The Sub-Panel Buttons along the top right of the screen.
6. The Sub-Panels on the right side of the screen.
7. The Real Time Dashboard along the bottom of the screen.
8. The Post Processing Dashboard replaces the Real Time Dashboard. while the program is in Post Processing mode.
9. The Status Bar Messages in the lower left corner.
10. The Information Center in the lower right corner.

An image of the interface is shown in Figure 6-1. Note that multiple 3D Displays can be rendered simultaneously.

Figure 6-1. EVaRT Interface in Real Time Mode


Menu Bar
Directory List
Mode Buttons
Sub-Panel Buttons
EVaRT
File Layouts Data Views Tools Help
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Tracking
Objects
Output
Graphic Panes
0.911 (51)
X
Y
Z
4.00
AvgResidual
0.00
F1X
F1Y
F1Z
M1X
M1Y
M1Z
F2X
F2Y
F2Z
M2X
M2Y
M2Z
Clear Entry
Select Markerset:
Local
System
Refresh
MarkerName Prefix Options
Merge Markersets
Panels
Tracking
Identifying
Skeleton
Join Virtual
Connect To Cameras
Disconnect - Use Raw Files
Run
Reset IDs
New Subject ...
All On
1
2
3
4
5
6
7
8
MotionAnalysis
Status Bar Messages
Real Time Dashboard
Information Center
(Cells 1 through 5)

Main Markerset: Body_Club_Merged.prj

Additional Tracking Objects:
A BodyOnly.prj
B ClubOnly.prj
C
D
E
F
G
H
I
J

Body_Club_Merged.prj
BodyOnly.prj
Calibration Only.prj
ClubOnly.prj

● None
○ A_B_, etc
○ MarkerSet Name Property

☑ Tracking
☑ Identifying
☑ Skeleton
☐ Join Virtual

○ Connect To Cameras ● Disconnect - Use Raw Files

GolfTemper1.vc1

464
00:00:03:104

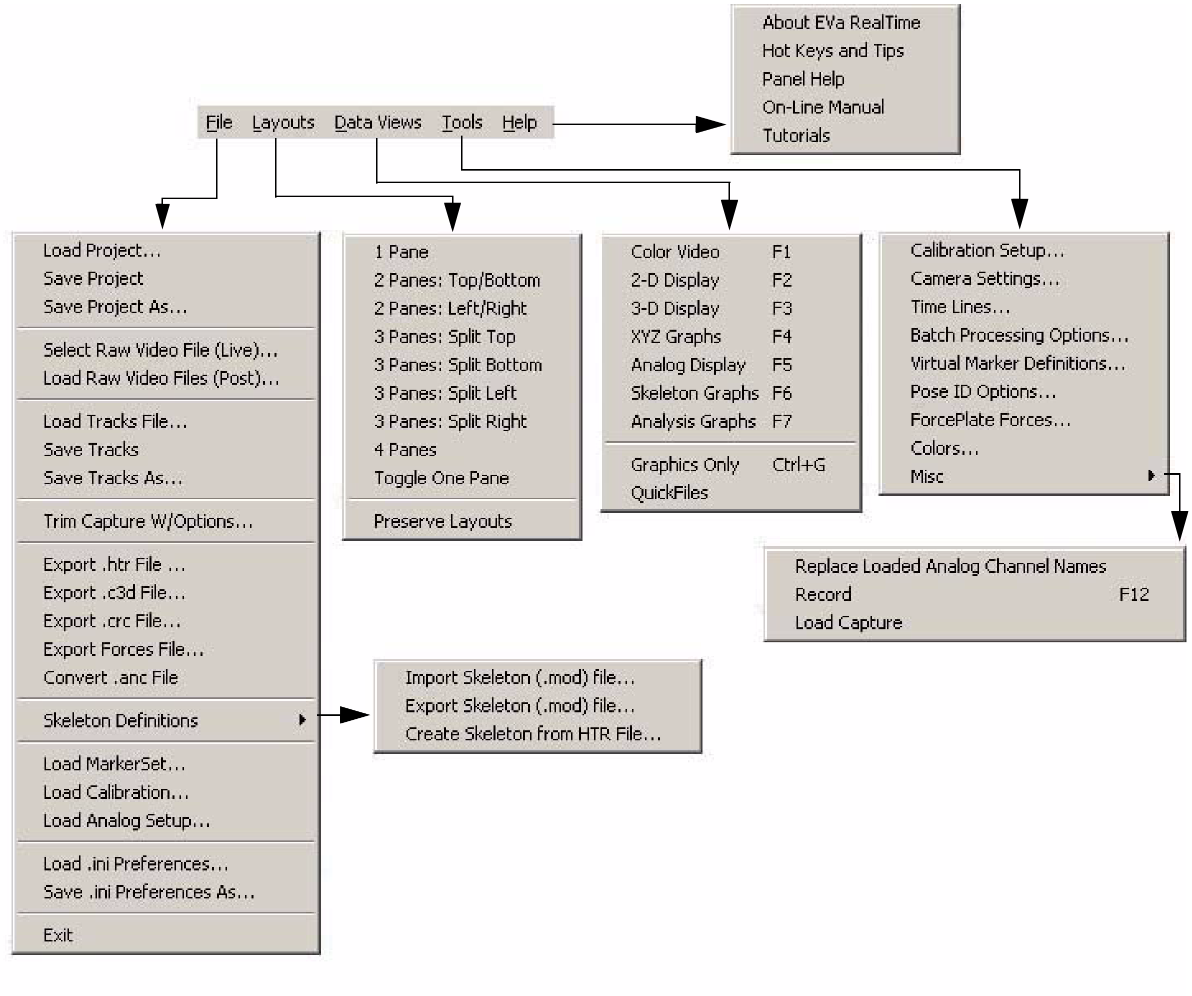
269 - Stopped

964 Frames | 120 FPS | Z-Up | Units:mm | Analog: 600 Hz

Menu Bar

The Menu Bar selects the primary menu items for **EVaRT** functionality. These include file management, layout control, data views, tools, and help.

Figure 6-2. Menu Bar


File Layouts Data Views Tools Help
About EVa RealTime
Hot Keys and Tips
Panel Help
On-Line Manual
Tutorials
Load Project...
Save Project
Save Project As...
Select Raw Video File (Live)...
Load Raw Video Files (Post)...
Load Tracks File...
Save Tracks
Save Tracks As...
Trim Capture W/Options...
Export .htr File ...
Export .c3d File...
Export .crc File...
Export Forces File...
Convert .anc File
Skeleton Definitions
Load MarkerSet...
Load Calibration...
Load Analog Setup...
Load .ini Preferences...
Save .ini Preferences As...
Exit
1 Pane
2 Panes: Top/Bottom
2 Panes: Left/Right
3 Panes: Split Top
3 Panes: Split Bottom
3 Panes: Split Left
3 Panes: Split Right
4 Panes
Toggle One Pane
Preserve Layouts
Color Video F1
2-D Display F2
3-D Display F3
XYZ Graphs F4
Analog Display F5
Skeleton Graphs F6
Analysis Graphs F7
Graphics Only Ctrl+G
QuickFiles
Calibration Setup...
Camera Settings...
Time Lines...
Batch Processing Options...
Virtual Marker Definitions...
Pose ID Options...
ForcePlate Forces...
Colors...
Misc
Replace Loaded Analog Channel Names
Record F12
Load Capture
Import Skeleton (.mod) file...
Export Skeleton (.mod) file...
Create Skeleton from HTR File...

File Menu

Load Project...

Loads a project file (.prj) from the current working directory.

Save Project

Saves a project file (.prj) to the current working directory.

Save Project As...

Provides a method to save the current project (PRJ) file under a different name.

Select Raw Video File (Live)...

Loads the VC (Raw Video) files from a capture session.

Load Raw Video Files (Post)...

This loads the raw data into the post process screen and is used for the Refine Tracks feature (see “Refine Tracks” on page 12-3). The data is the centroids calculated during the load.

Load Tracks...

Loads the TRB or TRC (Tracks) files from a capture session.

Save Tracks

Allows the user to save the current Tracks (TRB or TRC) file with the current filename.

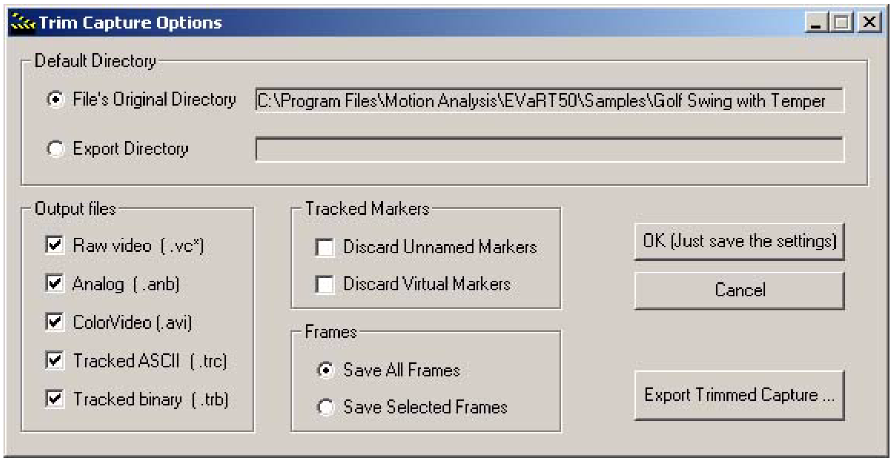
Save Tracks As...

Provides a method to save the current Tracks (TRB or TRC) file under a different name.This function will only allow you to change the file name, not the file type. To change the file type, you must use the **Export.xxx File...** menu item.

Trim Capture W/Options...

Provides frame and marker options when saving Tracks (TRB or TRC) files. The **Trim Capture** feature allows you to specify which directories the new files will be saved to, as well as frame and marker management options. Refer to Figure 6-3. The software remembers two folder names, the current folder, and the export folder.

Figure 6-3. Trim Capture w/Options Interface



Trim Capture Options

Default Directory

● File's Original Directory C:\Program Files\Motion Analysis\EVaRT50\Samples\Golf Swing with Temper

○ Export Directory

Output files

☑ Raw video (.vc*)

☑ Analog (.anb)

☑ ColorVideo (.avi)

☑ Tracked ASCII (.trc)

☑ Tracked binary (.trb)

Tracked Markers

☐ Discard Unnamed Markers

☐ Discard Virtual Markers

Frames

● Save All Frames

○ Save Selected Frames

Export HTR File...

Exports a file in HTR format, which is differently organized than the HTR2 format.

Export C3D File...

Exports marker positions and analog data in an open sourced file format viewable by many different software packages.

Export CRC File...

CRC (Centroid Row Column) data are the 2D data points in ASCII text format. Usable by advanced users who want to reconstruct 3D positions of markers using their own software, in post process mode only.

Export Forces File...

Exports ASCII files containing forceplate data. This uses your current forcepla.cal file and converts the raw forceplate data into calibrated forces. The units used are Newtons and Newton-Meters.

Convert .anc File...

Converts binary formatted Analog data (.anb) into an ASCII viewable format (.anc).

Skeleton Definitions

Import Skeleton (.mod) File...provides a method for bringing a new MOD file into the current PRJ file.

MOD files are used for Deep Solver applications. The name of the MOD file will match the marker set name as defined in the project.

Export Skeleton (.mod) File...provides a method for saving a MOD file for use in a different PRJ file.

Create Skeleton from HTR File...brings in the skeleton definitions from the animation package.

Load Marker Set...

Can be used to load a previous marker set into a new or newly calibrated project.

Load Calibration...

Can be used to load a new set of calibration information into a project.

Load Analog Setup...

Can be used to load a new set of analog setup information (forceplates, EMG, and others), into the current project.

Load .ini Preferences...

If the end user changes the look or feel of the software (different color scheme, sounds etc.) then when they move to a new version of the software (i.e. new release), they can load up their preferred 'look' and have that as the default start. You need to use save the .ini preferences (see below) to make this .ini file.

Save .ini Preferences...

If the end user changes the look or feel of the software (different color scheme, sounds etc.) then they must save their changes using this tool. Creates an INI file that can be loaded onto different computers or on new versions of the **EVaRT** software. See Load .ini Preferences.... above.

Exit

Allows you to exit the **EVaRT** software. Make sure you have saved the current project and tracks files.

Layouts Menu

The items in this menu are generally self explanatory.

Data Views Menu

The **EVaRT** interface can accommodate up to four simultaneously open data views and can be resized with the mouse to fit the panes however you desire. You can view combinations of six different graphical panes, which include:

Color Video F1

Shows the live action in a capture volume or a replay of an AVI file. You will need to have a DV (Digital Video) camera connected to the Host computer’s 1394 Firewire port to see the live video in this window.

2-D Display F2

Shows a 2D image of the markers and their centroids.

3-D Display F3

Displays a moving 3D stick figure showing named markers, virtual markers, linkages and/or a skeleton.

XYZ Graphs F4

Displays graphs depicting the marker's positions in each frame.

Analog Display F5

Displays analog data graphs representing the force plate's output.

Skeleton Graphs F6

Displays hierarchical translations and rotations of skeletal segments.

Analysis Graphs F7

Calculates and displays angles between markers, distances between markers, and position, velocity, and acceleration of a marker, or groups of selected markers. Results can be saved as ASCII Time Series (**.ts**) files. For more information, refer to Appendix K, Analysis.

Graphs Only (Ctrl+G)

Hides the side panels and Post Process/Realtime Dashboard to maximize the graphic panes.

Quickfiles

The Quickfiles display provides a window within the **EVaRT** interface to navigate the file structures and contents of the directories used for motion capture data sets. Specific file types can be chosen for display, which allows the user to filter out unwanted file types.

Tools Menu

The Tools menu gives access to various functions within the **EVaRT** software. Many of these functions are also available in other sections of the user interface.

Calibration Setup

The Calibration Setup defines the parameters for the system calibration (e.g. capture volume up-axis, calibration units, etc.). For complete information, refer to "Details... Button (Calibration Settings Window Tabs)" on page 8-4.

Edit Thresholds

This activates the threshold slider used to block out excessive noise in the 2D camera view. For more information, refer to "Adjusting Thresholds" on page 7-9.

Time Lines

Shows the time line of the data for each marker, indicating any breaks in the stream of data. More information can be found in "Time Lines" on page 10-26.

Batch Processing Options

This provides an overview of the tracking, identifying, and solving configuration in **EVaRT**. For complete information, refer to "Batch Processing" on page 9-13.

Virtual Marker Definitions

This sets the definition markers that are used to support a particular virtual marker. For complete information regarding Virtual Markers, refer to "Virtual Markers" on page 11-6.

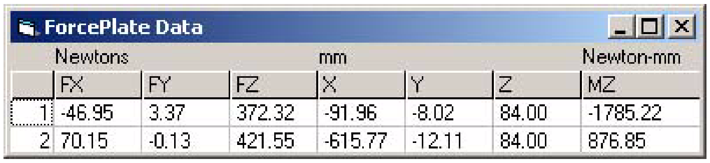
Pose ID Options

This is used to automatically identify markers based on a Model Pose that you create when you make a template. The result is that if you use the same marker set repeatedly, you will not have to ID the new person each time the marker set is used. This is the same function as using the **New Subject...** button that is found on the Real Time dashboard. For complete information, refer to "New Subject Button" on page 6-24.

Forceplate Forces

Selecting this feature will display the forceplate measurements in numerical values. This works when you are live and connected to the cameras, or when you are simulating Real Time from VC files and you are Post Processing mode.

Figure 6-4. Forceplate Forces

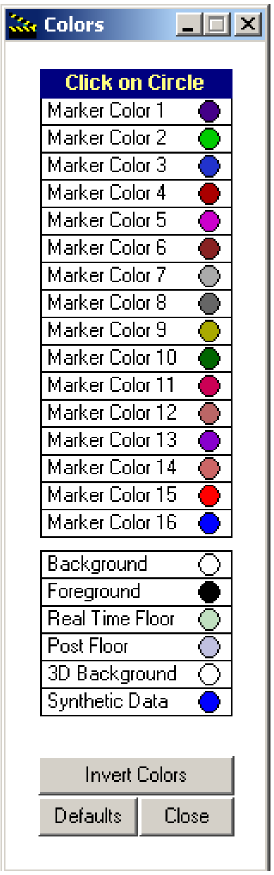


	Newtons			mm			Newton-mm
	FX	FY	FZ	X	Y	Z	MZ
1	-46.95	3.37	372.32	-91.96	-8.02	84.00	-1785.22
2	70.15	-0.13	421.55	-615.77	-12.11	84.00	876.85

Colors...

The Colors form allows you to choose RGB colors for the markers, Background, Foreground, Real-Time Floor, and Post Floor for your project. Refer to Figure 6-5.

Figure 6-5. Colors Form



Click on Circle	
Marker Color 1	●
Marker Color 2	●
Marker Color 3	●
Marker Color 4	●
Marker Color 5	●
Marker Color 6	●
Marker Color 7	●
Marker Color 8	●
Marker Color 9	●
Marker Color 10	●
Marker Color 11	●
Marker Color 12	●
Marker Color 13	●
Marker Color 14	●
Marker Color 15	●
Marker Color 16	●

Background	○
Foreground	●
Real Time Floor	●
Post Floor	●
3D Background	○
Synthetic Data	●

To change the color for any item, just click on the colored circle and a color palette window opens up. This lets you choose the color blend for that marker. The colors are stored in the **EVaRT50.ini** initialization file that is loaded from the **EVaRT** launch folder. They can also be stored in your personalized .ini file.

Misc

Replace Loaded Analog Channel Names—Occasionally, there are situations where an incorrect analog channel name can occur. Examples of this can be seen when analysis software (like OrthoTrak) requires specific muscle names for the analysis. In these cases the ability to go back and rename the problem analog channel is required.

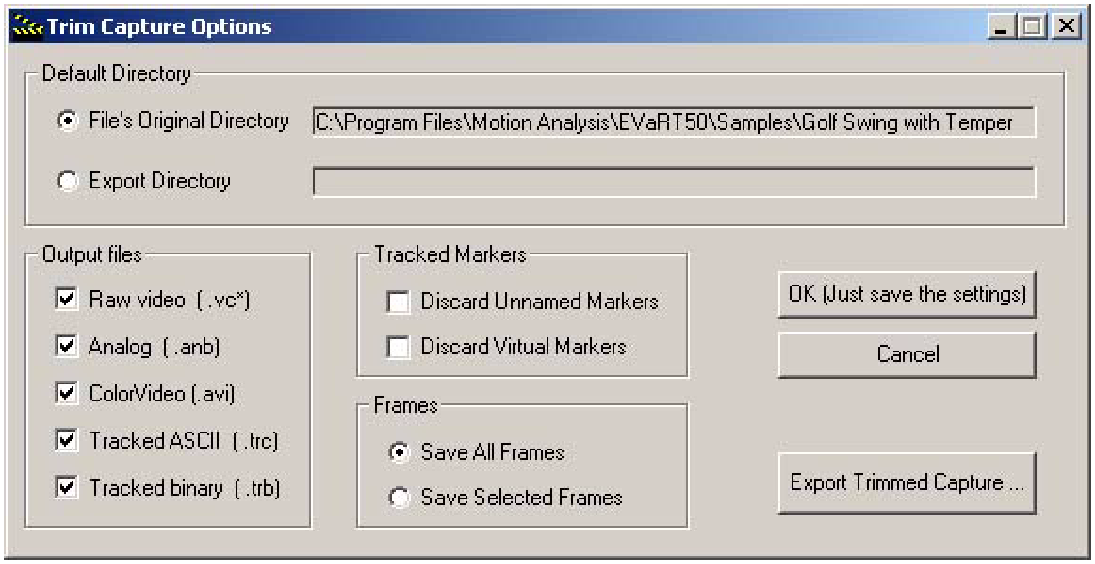
To Rename Analog Channels, follow these steps:

1. Load a Project file.
2. Load a Tracks (.trb/.trc) file.
3. Select **Data Views > Analog Display.**
4. In the existing project file, go to **Setup > Analog**, and change the name of the analog channel you wish to modify.
5. Save the project. You may want to save it as a different project name.
6. Go to the Tools menu and select **Misc > Replace Loaded Analog Channel Names**.
7. To see the replaced name, reload the project file you are working with. This will show the changed name in the Analog display sidebar.

Note: To save this change to the analog file, you must follow the next steps exactly.

8. Select **File > Trim Capture W/Options**.

Figure 6-6.



● File's Original Directory: C:\Program Files\Motion Analysis\EVaRT50\Samples\Golf Swing with Temper
○ Export Directory:
☑ Raw video (.vc*)
☑ Analog (.anb)
☑ ColorVideo (.avi)
☑ Tracked ASCII (.trc)
☑ Tracked binary (.trb)
☐ Discard Unnamed Markers
☐ Discard Virtual Markers
● Save All Frames
○ Save Selected Frames

9. Under the Trim Capture W/Options, choose **Save Selected Frames**. Make sure you have highlighted all the frames that you want by using the middle mouse button to highlight an area in the Post Processing window, or by using the Select All Frames button in the lower right corner.
10. Press the **Export Trimmed Capture** button, and type in the filename you want or keep the current one.
11. If you have more files that need to have the analog channel names replaced, you will need to repeat steps 2 through 10.

Record—The record function under the Tools menu item starts the recording of a data capture. It is the same function as the Record button found on the **Motion Capture > Output** sub-panel and the F12 function key.

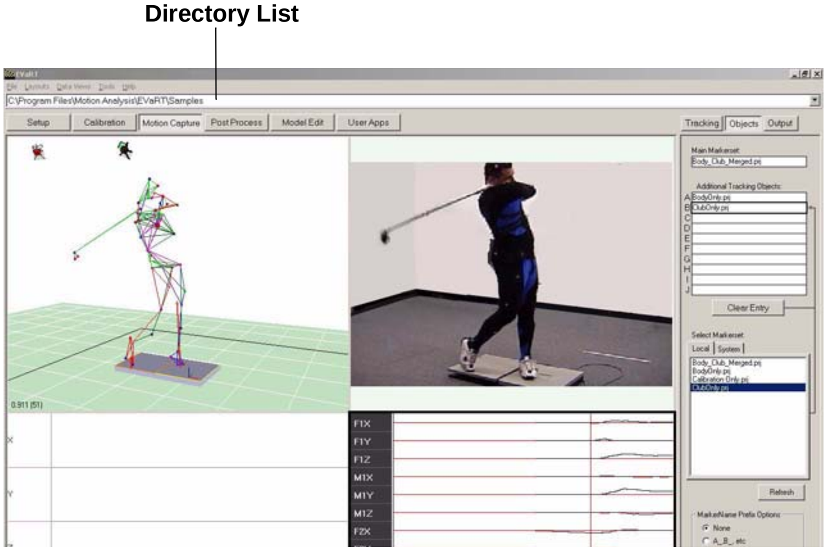
Help Menu

The Help menu provides information about the software, along with shortcuts, interface sub-panel information, and the on-line manual.

Directory List

The Directory List allows you to easily navigate through frequently used directories, making it easier to address and manage motion capture sessions. Refer to Figure 6-7.

Figure 6-7. Directory List


Directory List
EVaRT
File Layouts Data Views Tools Help
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Tracking
Objects
Output
Additional Tracking Objects:
A B C D E F G H I J
Clear Entry
Select Markerset
Local
System
Refresh
MarkerName Prefix Options
0.911 (51)
X
Y
F1X
F1Y
F1Z
M1X
M1Y
M1Z
F2X

C:\Program Files\Motion Analysis\EVaRT\Samples

Main Markerset: Body_Club_Merged.prj

A BodyOnly.prj
B ClubOnly.prj

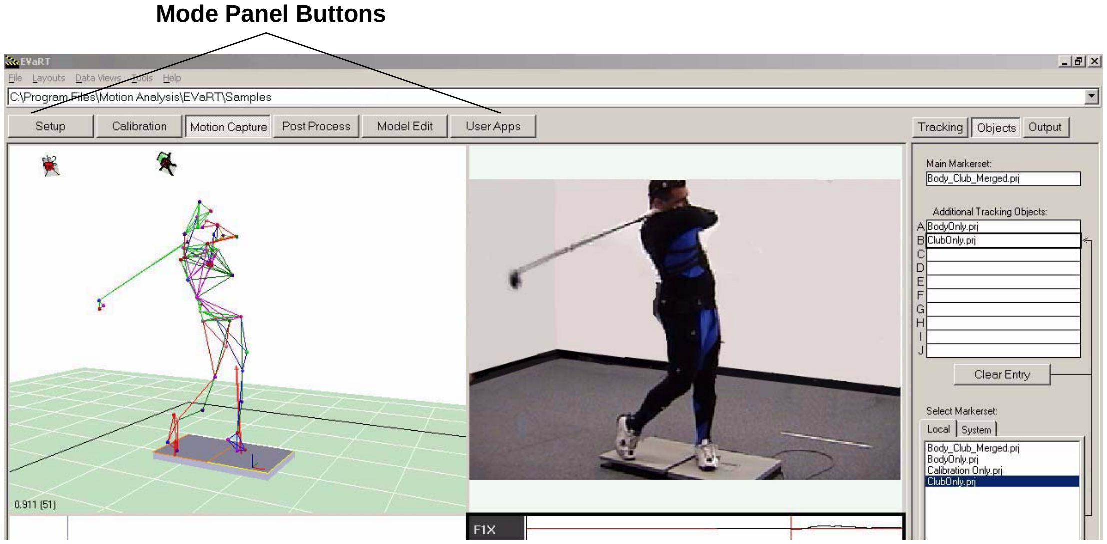
Body_Club_Merged.prj
BodyOnly.prj
Calibration Only.prj
ClubOnly.prj

● None
○ A_B_, etc

Mode Panel Buttons

These buttons are arranged to guide you through a motion capture session in a phase-oriented order. Refer to Figure 6-8. The first three mode buttons (Setup, Calibration, and Motion Capture) activate Real-Time mode and present you the necessary tools to successfully capture motion data.

Figure 6-8. Mode Panel Buttons


Mode Panel Buttons
EVaRT
File
Layouts
Data Views
Tools
Help
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Tracking
Objects
Output
Clear Entry
Local
System
0.911 (51)
F1X

C:\Program Files\Motion Analysis\EVaRT\Samples

Main Markerset: Body_Club_Merged.prj

Additional Tracking Objects:
A BodyOnly.prj
B ClubOnly.prj
C
D
E
F
G
H
I
J

Select Markerset:
Body_Club_Merged.prj
BodyOnly.prj
Calibration Only.prj
ClubOnly.prj

The fourth button, Post Process, activates Post Process mode and transforms **EVaRT** into a tracked data editing tool.

The final two buttons, Model Edit and User Apps, are mode-less function buttons that present various tools without switching the program between the Real-Time mode and Post Process mode. Model Edit is used to define markers to create linkages.

Sub-Panel Buttons

These buttons give you access to the various tools specific to the different phases of the motion capture session.

Status Bar Messages

This feature, located in the lower left corner of the user interface, provides the status and confirmation of the software in its current processing state.

Real Time Dashboard

Refer to “Real Time Dashboard” on page 6-23.

Information Center

The Information Center gives the following information for the current motion capture project (from left to right):

- Cell 1: Number of frames in the current data set
- Cell 2: Frame rate in frames per second
- Cell 3: Up axis (e.g. Y up, Z up)
- Cell 4: Calibration units (e.g. mm)
- Cell5: Analog sample rate (samples/sec)

If you leave the mouse pointer over the message, its definition will pop up.

PRJ Files

PRJ files, or project files, are the main files used in gathering all **EVaRT** motion capture data. Every motion capture session must have a project file containing all system settings, equipment parameters, and other information related to the project. This file contains both equipment parameters common to many different setups and calibration values unique to one particular session. Among the data found in a project file are:

- the camera setup
- the marker set
- calibration setup and results
- linkages between markers
- SkB (Skeleton Builder) segment definitions, coordinate systems, and hierarchies (optional)—refer to Chapter 12, Skeleton Types
- MoCap Solver segment definitions, joint types, and hierarchies (optional)
- camera type and parameters
- tracking parameters

In most cases, you will begin a session by loading an existing project file, editing it as necessary, and saving it in the directory where the motion data is to be saved. Any time you calibrate the system or edit project parameters, you should save the project file to disk to retain the new information.

Note: Multiple PRJ files should be saved in the same file directory with care.

Important Project files contain ASCII data and it may be useful to view them using any text editor, however, you should not edit them in a text editor as that can result in a corrupt file.

Viewing Sample Data

To become familiar with **EVaRT**, we will start by replaying some sample data. This is done by loading a sample project found in the Samples directory.

Sample Data Set

1. From the Menu Bar, select **File > Load Project...**
2. Navigate to:
   Program Files\Motion Analysis\EVaRT50\Samples\GolfSwings with Temper.
3. Double-click on **Body_Club_Merged.prj** to load the project.

Having loaded the sample project, we will now load the related data files.

1. Select **Raw Files** on the Real Time Dashboard.
2. Click on **GolfTemper1.vc1**.

Click the **Run** button on the Real Time Dashboard. At this point the action on the screen is a simulation of a live motion capture session. **EVaRT** is processing the data from the stored raw video file, color video file, and analog file generated by the force plates. If this were an actual real-time capture session, the action on the screen would be similar, but the data would be coming directly from the cameras and force plates.

Note: Loading a VC file or TRB file will automatically load any saved ANB files captured during this session of this particular project. The ANB files are comprised of analog forceplate data in this example.

Having loaded all of the related data files, we can now exercise all of the six different Graphics Panes available to us. We will now look at four simultaneously.

1. From the Menu Bar, select **Layouts > 4 Panes**.
2. Left-click on the empty lower-left pane. This action will select this pane.
3. Press **F1** on the keyboard or choose **View > Color Video**.

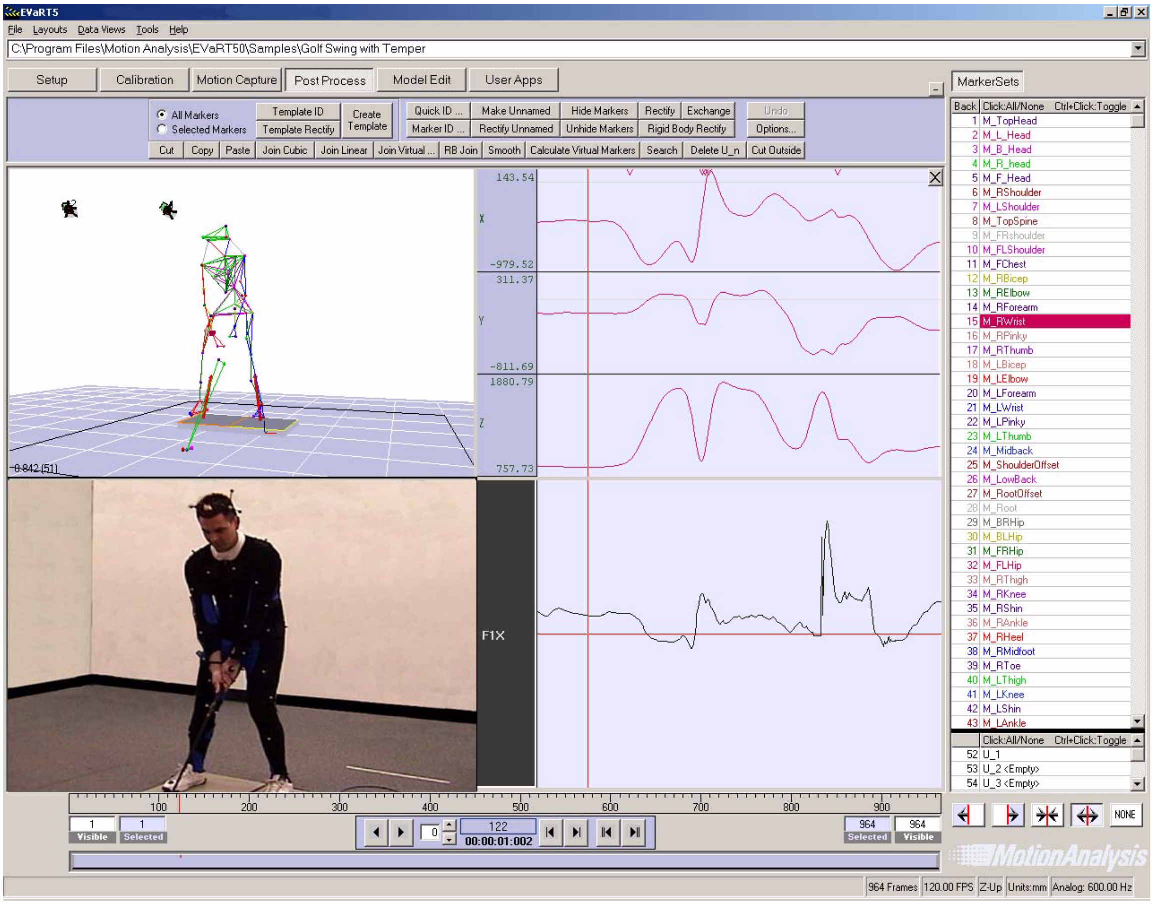
Note: If you are interested in the Color Video option, contact your Motion Analysis sales representative.

4. Left-click on the empty upper-right pane.
5. Press **F2** on the keyboard or choose **View > 2D Display**.
6. Left-click on the empty lower right pane.
7. Press **F5** on the keyboard or choose **View > Analog Display**.

The displays can be controlled by hand if you click **Pause**, click on the FIFO slider on the Real Time Dashboard, and then drag from side to side. The "First In First Out" FIFO slider can only manipulate the 256 frames of data that are currently stored in the FIFO memory space (but not all of the data in the data set).

Figure 6-9 should be similar to what you see on your screen.

Figure 6-9. Viewing the Pre-Recorded Data


EVaRT5
File Layouts Data Views Tools Help
C:\Program Files\Motion Analysis\EVaRT50\Samples\Golf Swing with Temper
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
MarkerSets
All Markers
Selected Markers
Template ID
Template Rectify
Create Template
Quick ID ...
Marker ID ...
Make Unnamed
Rectify Unnamed
Hide Markers
Unhide Markers
Rectify
Exchange
Rigid Body Rectify
Undo
Options...
Cut
Copy
Paste
Join Cubic
Join Linear
Join Virtual ...
RB Join
Smooth
Calculate Virtual Markers
Search
Delete U_n
Cut Outside
143.54
X
-979.52
311.37
Y
-811.69
1880.79
Z
757.73
F1X
0.842 (51)
Back Click:All/None Ctrl+Click:Toggle
1 M_TopHead
2 M_L_Head
3 M_B_Head
4 M_R_head
5 M_F_Head
6 M_RShoulder
7 M_LShoulder
8 M_TopSpine
9 M_FRshoulder
10 M_FLShoulder
11 M_FChest
12 M_RBicep
13 M_RElbow
14 M_RForearm
15 M_RWrist
16 M_RPinky
17 M_RThumb
18 M_LBicep
19 M_LElbow
20 M_LForearm
21 M_LWrist
22 M_LPinky
23 M_LThumb
24 M_Midback
25 M_ShoulderOffset
26 M_LowBack
27 M_RootOffset
28 M_Root
29 M_BRHip
30 M_BLHip
31 M_FRHip
32 M_FLHip
33 M_RThigh
34 M_RKnee
35 M_RShin
36 M_RAnkle
37 M_RHeel
38 M_RMidfoot
39 M_RToe
40 M_LThigh
41 M_LKnee
42 M_LShin
43 M_LAnkle
Click:All/None Ctrl+Click:Toggle
52 U_1
53 U_2 <Empty>
54 U_3 <Empty>
100 200 300 400 500 600 700 800 900
1 Visible
1 Selected
0
122
00:00:01:002
964 Selected
964 Visible
NONE
MotionAnalysis
964 Frames
120.00 FPS
Z-Up
Units:mm
Analog: 600.00 Hz

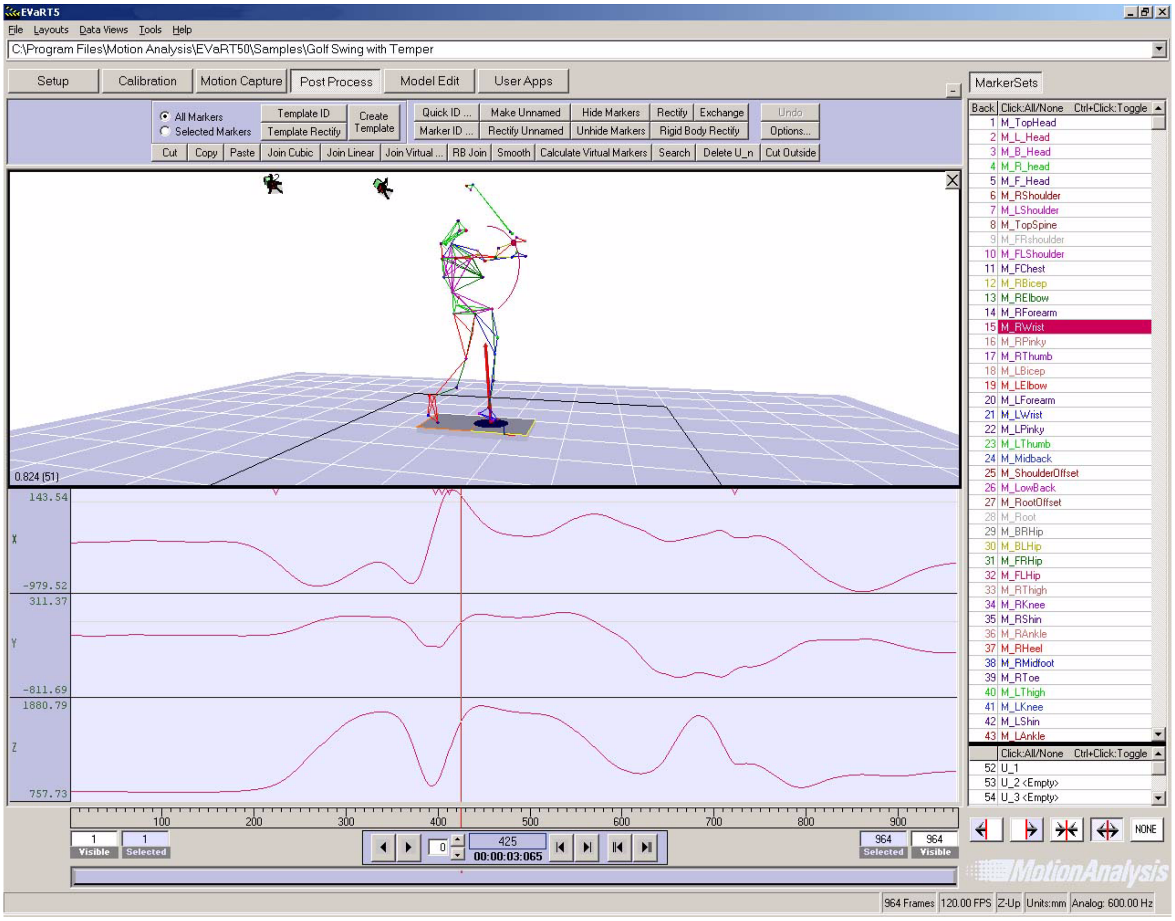
EVaRT displays data somewhat differently when in Post Process mode. For instance, the analog displays become static graphs rather than having the oscilloscope style seen during collection and replays of raw data. The 2D Display and Skeleton Graphs become entirely unavailable but the XYZ Graphs become available. 3D stick figure images can be rendered for all of the data set rather than just the 256 frames available in Real-Time mode.

Post Process mode allows you to edit the tracked data generated during a motion capture session. Editing can be performed upon groups of markers or one marker at a time.

1. From the Menu Bar, select **File > Load Tracks File...**
2. Double-click on **GolfTemper1.trb**.
3. Leave the 3D figure currently in the top pane in the 3D Display.
4. From the Menu Bar, select **Layouts > 2 Panes: Top/Bottom**.
5. Left-click on the bottom pane. This action will select this pane.
6. Press **F4** on the keyboard or choose **View > XYZ Graphs**.
7. Select marker 15 on the Markerset panel (right side).

The two Graphics Panes used, often simultaneously, during a Post Process editing session are the 3D Display and the XYZ Graphs shown here. Notice that the Post Process Dashboard has replaced the Real Time Dashboard. The data shown in the XYZ Graphs represents the X, Y, and Z coordinates of the selected markers throughout the capture period.

Figure 6-10. Viewing Tracked Data in Post Process Mode


EVaRT5
File Layouts Data Views Tools Help
C:\Program Files\Motion Analysis\EVaRT50\Samples\Golf Swing with Temper
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
MarkerSets
All Markers
Selected Markers
Template ID
Template Rectify
Create Template
Quick ID ...
Marker ID ...
Make Unnamed
Rectify Unnamed
Hide Markers
Unhide Markers
Rectify
Exchange
Rigid Body Rectify
Undo
Options...
Cut
Copy
Paste
Join Cubic
Join Linear
Join Virtual ...
RB Join
Smooth
Calculate Virtual Markers
Search
Delete U_n
Cut Outside
0.824 (51)
143.54
X
-979.52
311.37
Y
-811.69
1880.79
Z
757.73
100
200
300
400
500
600
700
800
900
1 Visible
1 Selected
0
425
00:00:03:065
964 Selected
964 Visible
NONE
964 Frames
120.00 FPS
Z-Up
Units:mm
Analog: 600.00 Hz
Back
Click:All/None
Ctrl+Click:Toggle
1 M_TopHead
2 M_L_Head
3 M_B_Head
4 M_R_head
5 M_F_Head
6 M_RShoulder
7 M_LShoulder
8 M_TopSpine
9 M_FRshoulder
10 M_FLShoulder
11 M_FChest
12 M_RBicep
13 M_RElbow
14 M_RForearm
15 M_RWrist
16 M_RPinky
17 M_RThumb
18 M_LBicep
19 M_LElbow
20 M_LForearm
21 M_LWrist
22 M_LPinky
23 M_LThumb
24 M_Midback
25 M_ShoulderOffset
26 M_LowBack
27 M_RootOffset
28 M_Root
29 M_BRHip
30 M_BLHip
31 M_FRHip
32 M_FLHip
33 M_RThigh
34 M_RKnee
35 M_RShin
36 M_RAnkle
37 M_RHeel
38 M_RMidfoot
39 M_RToe
40 M_LThigh
41 M_LKnee
42 M_LShin
43 M_LAnkle
Click:All/None
Ctrl+Click:Toggle
52 U_1
53 U_2 <Empty>
54 U_3 <Empty>
MotionAnalysis

Pop-Up Menus

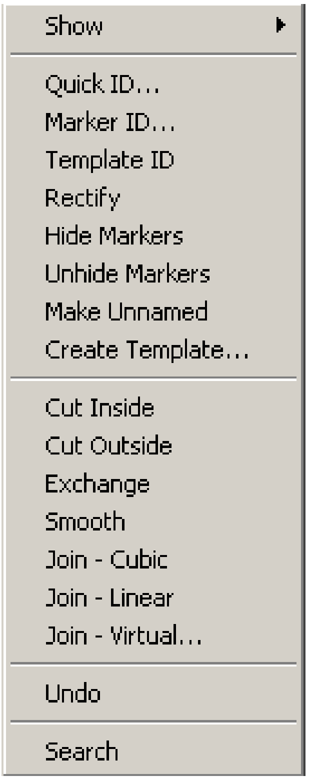
The Graphics Panes have viewing options and associated tools that can be accessed through pop-up menus. In all cases, the pop-up menus are activated with a click of the right mouse button while the pointer is in the display region.

3D Display Pop-Up Menu

1. From the Menu Bar, select **Layouts > 1 Pane**.
2. From the Mode Buttons, left-click on the Post Process button in order to be in the Post Process mode.
3. If the 3D Display is not visible, press **F3** on the keyboard or choose **View > 3D Display** from the Menu Bar.
4. With the right mouse button, click on the 3D Display.

The 3D Display pop-up menu and descriptions of the tools are shown in Figure 6-11. These options are recorded in your INI file and are reloaded when you launch **EVaRT**.

Figure 6-11. Post Process 3D Display With Pop-Up Menu Items

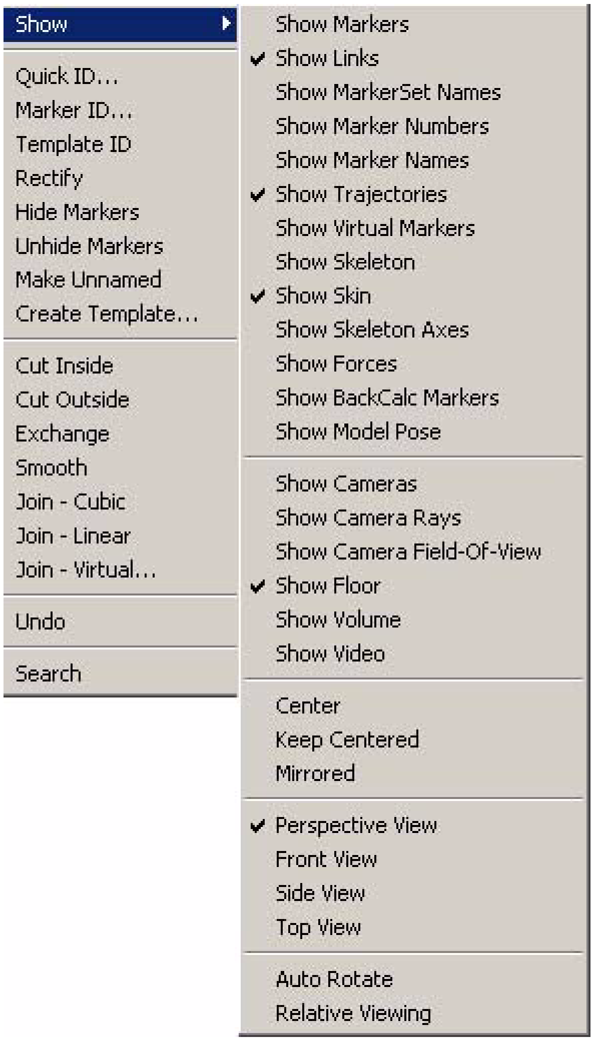


Show ▸	**Show options—cascading menu**
Quick ID...	**Quick ID the markers sequentially**
Marker ID...	**Marker ID the selected marker**
Template ID	**ID marker(s) based on current template**
Rectify	**Rectify marker(s) over the selected frame range**
Hide Markers	**Hide selected marker(s) from view**
Unhide Markers	**Show selected marker(s)**
Make Unnamed	**Make selected marker(s) unnamed**
Create Template...	**Create Template**
Cut Inside	**Cut data in selected frames from the selected marker(s)**
Cut Outside	**Cut data outside of the selected frames from the selected marker(s)**
Exchange	**Exchange data between two markers over the selected frames**
Smooth	**Smooth selected marker(s) over the selected frames**
Join - Cubic	**Join selected marker(s) over selected frames using cubic splines**
Join - Linear	**Join selected marker(s) over selected frames using linear interpolation**
Join - Virtual...	**Create a temporary virtual marker to fill in missing marker data**
Undo	**Undo last action**
Search	**Search data set for spikes and/or gaps as defined in the Options panel**

To see the 3D Display options:

1. Choose the cascading **Show** item and another pop-up list will appear. Several of the view options will have check marks next to them indicating they are active. All of the Show items in the Show list are considered User Preferences and get stored to the **EVaRT.ini** file when you exit the program.
2. Choose items from the Show options menu and see the effects. These options are saved in your INI file settings and are reloaded when you launch **EVaRT**.

Figure 6-12. 3D Display Right-Click Pop-Up View Options


Show
Quick ID...
Marker ID...
Template ID
Rectify
Hide Markers
Unhide Markers
Make Unnamed
Create Template...
Cut Inside
Cut Outside
Exchange
Smooth
Join - Cubic
Join - Linear
Join - Virtual...
Undo
Search
Show Markers
✓ Show Links
Show MarkerSet Names
Show Marker Numbers
Show Marker Names
✓ Show Trajectories
Show Virtual Markers
Show Skeleton
✓ Show Skin
Show Skeleton Axes
Show Forces
Show BackCalc Markers
Show Model Pose
Show Cameras
Show Camera Rays
Show Camera Field-Of-View
✓ Show Floor
Show Volume
Show Video
Center
Keep Centered
Mirrored
✓ Perspective View
Front View
Side View
Top View
Auto Rotate
Relative Viewing

Displays all markers in 3D display; Options... for length
Displays all links between markers in the 3D Display
Displays the prj file name over the marker cloud
Displays the ID numbers for all markers
Displays the marker names (over the marker)
Displays the marker trajectories (in PP mode only)
Displays the virtual markers
Displays the skeleton segments when they are defined
Displays a selected skin
Displays the RGB/XYZ orientation for each bone
Displays the force vectors off the forceplates
Displays the marker locations as defined in the T-pose
Displays the model pose as defined in Create Template

Displays the motion capture cameras in the 3D Display
Displays which cameras can see the selected marker(s)
Displays the camera view for the selected camera(s)
Displays the virtual floor in the 3D Display
Displays the capture volume; Calibration Details...
Displays the Digital Video layered with the 3D Display

Centers the display on the selected marker
3D Display center follows the selected marker
Mirrors marker set from left to right hand coordinates

Normal display, adjust with mouse
Show front view
Show side view
Show top view

Rotate around the capture area by pressing Play
Toggle display to view from selected markers

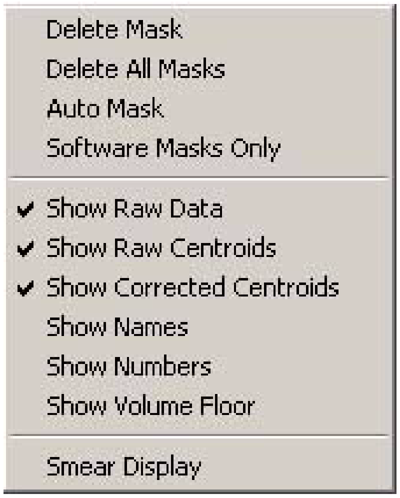
2D Display Pop-Up Menu

The 2D Display renders raw camera data as blobs and/or marker centroids. You can choose to see the centroids either with or without lens correction. To see the marker data as viewed from any one of the cameras or multiple cameras simultaneously,

1. Press **F2** on the keyboard or choose **View > 2D Display** from the Menu Bar.
2. Choose one or more cameras with **Ctrl** + click or **Shift** + click on the green camera buttons on the Real Time Dashboard or press **All On**.

To see the 2D Display options, right-click on the camera view 2D Display.

Figure 6-13. 2D Display with Pop-Up View Options


Delete Mask
Delete All Masks
Auto Mask
Software Masks Only
✓ Show Raw Data
✓ Show Raw Centroids
✓ Show Corrected Centroids
Show Names
Show Numbers
Show Volume Floor
Smear Display

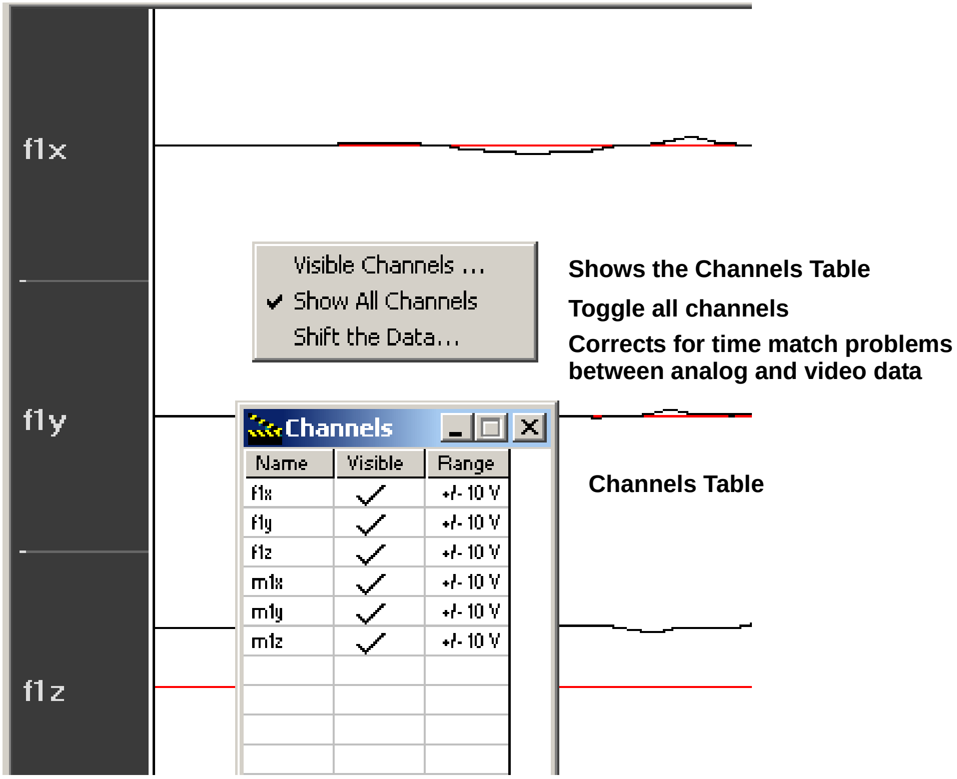
Deletes selected mask
Deletes all masks in the 2D display for the selected camera
Draws a mask around all items in the field of view
Allows the capture of raw data with any masks in 2D display
Toggle black raw data blobs
Toggle red, raw centroid crosses
Toggle centroids corrected from lens distortion
Toggle marker names
Toggle marker numbers
Toggle outline of volume floor
Leave smeared paths of markers

Analog Display Pop-Up Menu

For users collecting analog data from force plates, an Analog Display provides graphs of output from up to 64 analog channels. You can view any combination of channels at the same time. As a convenience, the Analog Display allows you to resize the label panel on the left side of the screen to accommodate long channel names. To open the Analog Display and modify the number of visible channels:

1. Press **F5** on the keyboard or choose **View > Analog Display** from the Menu Bar.
2. With the right mouse, click on the Analog Display.
3. From the pop-up menu, choose **Visible Channels...**
4. Left-click on any one of the check marks in the Visible column.
5. Press **Shift** + click in the **Visible** column to toggle multiple channels.
6. Click directly on the **Visible** header cell to toggle all of the channels at once.

Figure 6-14. Analog Display With Pop-Up View Options and Channels Table



Name	Visible	Range
f1x	✓	+/- 10 V
f1y	✓	+/- 10 V
f1z	✓	+/- 10 V
m1x	✓	+/- 10 V
m1y	✓	+/- 10 V
m1z	✓	+/- 10 V

Shows the Channels Table

Toggle all channels

Corrects for time match problems between analog and video data

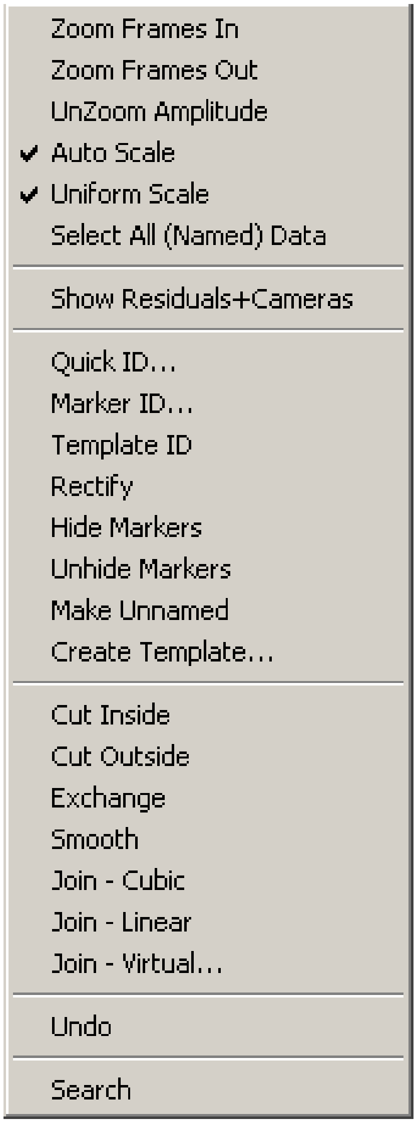
Channels Table

XYZ Graphs Pop-Up Menu

Post Process mode allows you to edit tracked data. The XYZ Graphs displays the positions of each marker in each frame. It also lets you select and edit those markers in any frame. A complete discussion of editing tracked data can be found in Chapter 10, Post Processing Panel. To see the XYZ Graphs and the pop-up menu of tools and view options:

1. Press **F4** on the keyboard or choose **View > XYZ Graphs**.
2. When in Post Process mode, right-click on the XYZ Graphs.

Figure 6-15. Post Process XYZ Graphs With Pop-Up View Options and Tools


Zoom Frames In
Zoom Frames Out
UnZoom Amplitude
✓ Auto Scale
✓ Uniform Scale
Select All (Named) Data
Show Residuals+Cameras
Quick ID...
Marker ID...
Template ID
Rectify
Hide Markers
Unhide Markers
Make Unnamed
Create Template...
Cut Inside
Cut Outside
Exchange
Smooth
Join - Cubic
Join - Linear
Join - Virtual...
Undo
Search

Zoom into the current frame range

Zoom out from the current frame range

Reset the amplitude display

Auto scale to visible channels

Applies uniform scale to all three X, Y, and Z panels

Select all frames in the data set

Show Residuals and Cameras plots

Quick ID the markers sequentially

Marker ID the selected marker

ID marker(s) based on current template

Rectify marker(s) over the selected frame range

Hide selected marker(s) from view

Show selected marker(s)

Make selected marker(s) unnamed

Create Template

Cut data in selected frames from the selected marker(s)

Cut data outside of the selected frames from the selected marker(s)

Exchange data between two markers over the selected frames

Smooth selected marker(s) over the selected frames

Join selected marker(s) over selected frames using cubic splines

Join selected marker(s) over selected frames using linear interpolation

Create a temporary virtual marker to fill in missing marker data

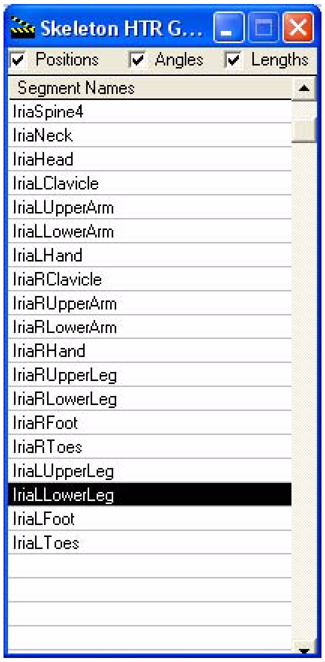
Undo last action

Search for spikes and/or gaps; as defined in the Options panel

Skeleton Graphs Pop-Up Menu

The Skeleton Graphs pop-up menu offers a single item menu which opens the Skeleton Graphs Control panel as shown in Figure 6-16. This control panel allows you to control the segments that are shown in the graphs and control the chart style and colors of the display. You must have a skeleton defined with either **Calcium/Si** or **SkB** (Skeleton Builder) for this to work. A skeleton defines joint centers and segments according to the rules of the modeling. The **Calcium/Si** software is used to generate Solver skeletons. **EVa 6.0** or **7.0** can be used to define **SkB** skeletons.

Figure 6-16. Skeleton HTR Graphs Pop-Up Menu—Control Panel



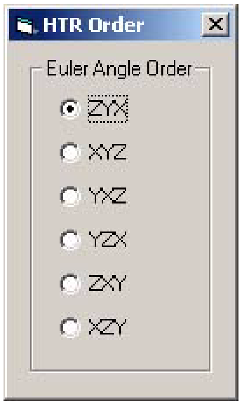
☑ Positions ☑ Angles ☑ Lengths

Segment Names
- IriaSpine4
- IriaNeck
- IriaHead
- IriaLClavicle
- IriaLUpperArm
- IriaLLowerArm
- IriaLHand
- IriaRClavicle
- IriaRUpperArm
- IriaRLowerArm
- IriaRHand
- IriaRUpperLeg
- IriaRLowerLeg
- IriaRFoot
- IriaRToes
- IriaLUpperLeg
- IriaLLowerLeg
- IriaLFoot
- IriaLToes

HTR Order (Euler Angle Order)

This sets the rotation sequence, with the first letter being the axis of the angle (flexion/extension point).

Figure 6-17. HTR Order (Euler Angle Order)



Euler Angle Order
- ● ZYX
- ○ XYZ
- ○ YXZ
- ○ YZX
- ○ ZXY
- ○ XZY

Digital Video Option (EVaDV Software)

The color Digital Video option allows you to record a time-matched Reference Video along with your motion capture trial on a separate computer. With this option, you will record a time-matched color video AVI file with the same trial name in your motion capture folder. A separate computer is used in order to not burden your **EVaRT** Host computer, which is an issue if your computer is too slow for the number of markers being tracked. For single person captures, you may connect the DV Camera directly to the **EVaRT** Host computer. In this case, the **EVaDV** software is not needed. It is built into the **EVaRT** software. You can run **EVaDV** on one or more computers and then capture multiple AVI files (multiple views). They will all have the same AVI file name. You may experience a small delay in frames from the **EVaRT** software and the **EVaDV** software when capturing. The Color Video display has a pop-up menu with one item, Adjust Frame Offset. This allows for time-matching data streams.

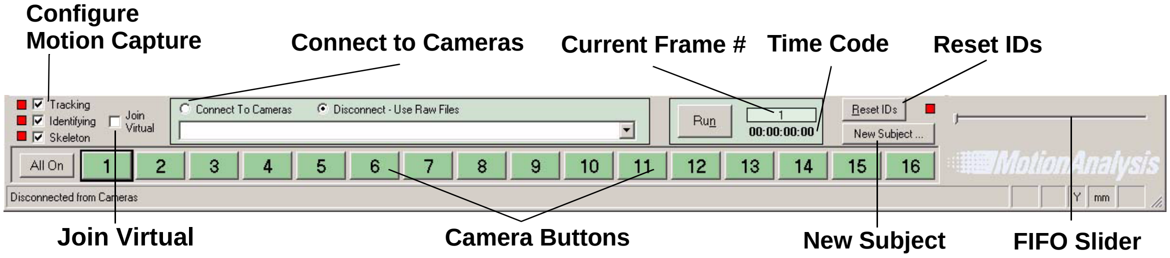
Note: The **EVaDV** software option is not to be confused with the AVI function in the **Motion Capture > Output** sub-panel. This function creates an AVI file within the **EVaRT** project file.

Real Time Dashboard

The Real Time Dashboard is available when **EVaRT** is in Real Time mode as opposed to Post Process mode. When you are capturing data in real-time, this dashboard provides the controls to manage a motion capture session. It also supports the replay and tracking of previously recorded data with a simulation of real-time from the raw VC camera files.

Note: To help you distinguish between the two modes (Real Time and Post Process), the dashboard and the floor color changes.

Figure 6-18. Real Time Dashboard


Configure Motion Capture
Connect to Cameras
Current Frame #
Time Code
Reset IDs
Run
Reset IDs
New Subject ...
All On
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
MotionAnalysis
Y
mm
Join Virtual
Camera Buttons
New Subject
FIFO Slider

☑ Tracking
☑ Identifying
☑ Skeleton
☐ Join Virtual
○ Connect To Cameras ● Disconnect - Use Raw Files
1
00:00:00:00
Disconnected from Cameras

EVaRT Dashboard Camera Button Colors

The Real Time Dashboard camera buttons inform you of the following:

Green	Camera is completely calibrated
Light green	Camera is completely calibrated and is selected
Yellow	Camera has undergone seed calibration but not wand calibration
Light yellow	Camera has undergone seed calibration and is selected
White	Camera is not calibrated
Dark grey	Camera is inactive—A right mouse click on the camera number will enable and disable that camera. **Note**—Camera #1 must remain enabled when you collect data to make sure you have a selectable VC1 file.

Tracking

The Tracking check box triangulates (tracks) the markers from frame to frame. You might want to uncheck this if your computer is not fast enough to calculate the marker coordinates or if your system is not calibrated for any reason. You can still collect raw VC files and track them at a later time. Collecting raw VC files is the highest priority thread in the motion capture Record mode to ensure that you do not lose your raw data.

Identifying

The Identifying check box identifies and names the tracked markers according to the current template. If you do not have a template, it is best to disable this function to keep the software from attempting to ID the data.

Skeleton

The Skeleton check box is set to calculate the skeleton using the currently active skeleton model.

Reset IDs Button

The Reset IDs button forces the current template to be used for that specific frame. It is used when a marker is misidentified. Press this if you see markers that are incorrectly identified. If this fails to fix the problem, you may need to create a new template or adjust the marker set to be less symmetric. After pressing the **New Subject...** button and with the Pose ID window open, the Reset ID button will use the current marker pose to identify the markers.

New Subject Button

This feature allows the software to automatically identify markers based on a Model Pose that you create when you make a template. The result is that if you use the same marker set repeatedly, you will not have to ID the new person each time the marker set is used. The marker identification is automatic and instant, saving you time.

The Model Pose has its own kind of generalized template that is used to automatically identify a new person when they appear in the field of view. It saves the steps of using the Quick ID feature to identify a new person in order to make a template for them. The Auto ID feature works in the

Real-Time mode when you are connected to cameras or it works when you are tracking the data from VC files after the collection.

Note: The current template is size specific, so a new person or a new arrangement in the markers will not generally work for automatically identifying the markers.

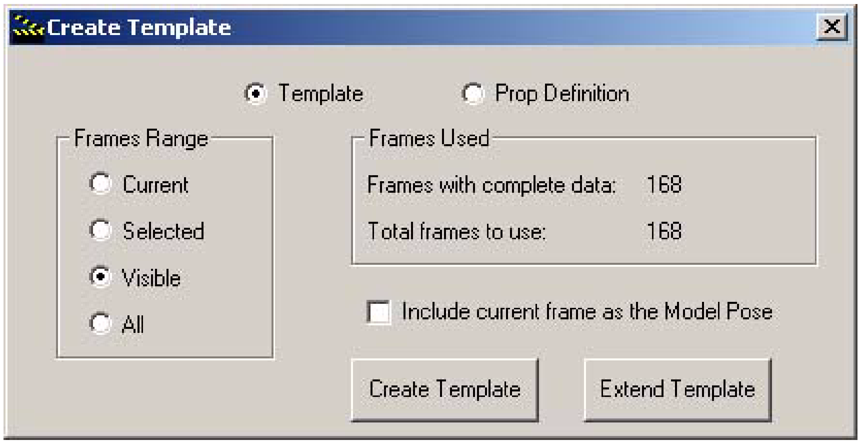
When you click **Update Template**, it also updates the Model Pose.

To use the **New Subject** button, use the following procedure:

1. Get a Range-of-Motion Trial.
   a. Get a good range of motion trial for your current tracks in Post Process, Quick ID, and edit so there are no mistakes or marker switches. The data does not have to be highly complex, but it should represent the minimum and maximum stretching for all limbs. Jumping Jacks are a good example of the kind of dynamic motion that has worked well and does not obscure the markers or require editing. For simple walking motion, a single walking trial will suffice.
   b. Select one frame that represents a standard or neutral pose position. This can be with the arms down or the arms out, feet apart or together, but where no markers will be hidden. You will want it to be a standard position that the next person will be able to repeat quickly and simply. Have them face a certain direction that will also be easily repeatable for the next person. (along the +X axis for example).
2. Create a Template.
   a. Select **Post Process > Create Template.**
   b. Select Body Template and check the box **Include current frame as the Model Pose** and select the correct range of frames where you have good data.
   c. Save your project file which now has a new feature called the Model Pose stored in it. You may want to use the word “Pose" in the project file name to distinguish it from earlier versions without the pose, but that is not necessary. The normal template will also work for this person.

Note: You can choose to see the Model Pose in your current project by right-clicking in the 3D display and then selecting **Show > Show Model Pose**.

Figure 6-19. Create Template Window—Include Current Frame as the Model Pose


Create Template

● Template ○ Prop Definition

Frames Range
○ Current
○ Selected
● Visible
○ All

Frames Used
Frames with complete data: 168
Total frames to use: 168

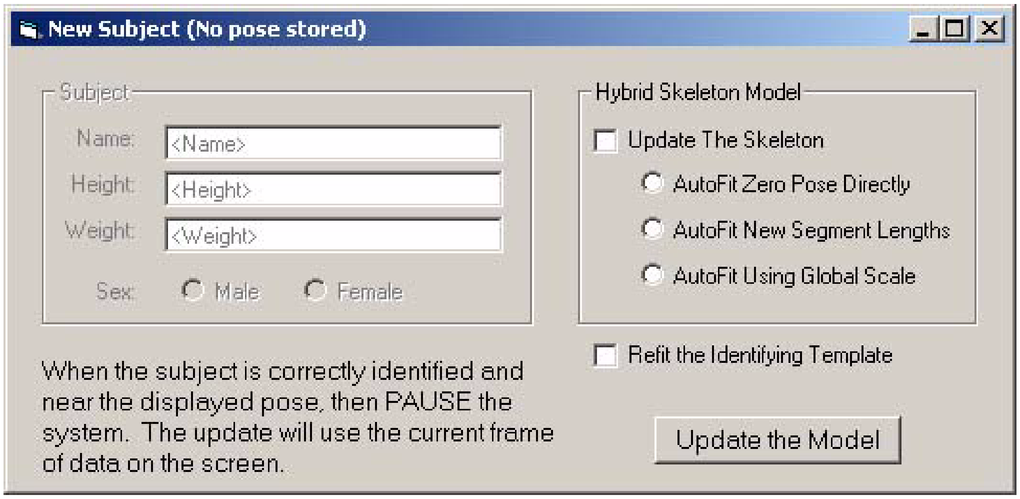
☐ Include current frame as the Model Pose

Getting Auto ID to Work: Tuning and Updating the Template

If the person who was used to create the template moves some markers, or if a new person comes out with the same marker configuration (but in slightly different locations), you will want to update the template to the new marker locations. This will make sure that your RealTime tracking and the Template ID and Template Rectify functions in Post Process will be at an optimum performance level.

Activate the Motion Capture panel and then select **Connect to Cameras** (or select the VC files) and then select **New Subject...**. This will bring up the Pose ID dialog box (below) and the Model Pose stick figure appears in the 3D panel.

Figure 6-20. New Subject... Interface


New Subject (No pose stored)

Subject
Name: <Name>
Height: <Height>
Weight: <Weight>
Sex: ○ Male ○ Female

Hybrid Skeleton Model
☐ Update The Skeleton
○ AutoFit Zero Pose Directly
○ AutoFit New Segment Lengths
○ AutoFit Using Global Scale

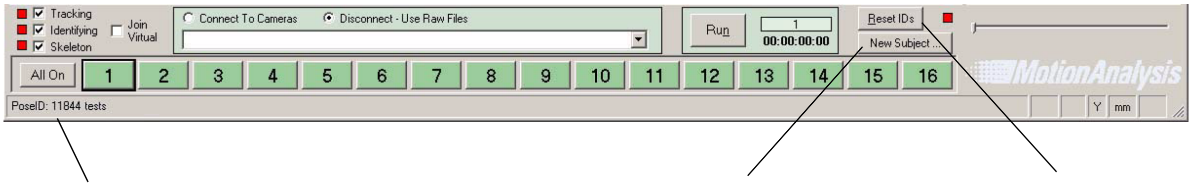
☐ Refit the Identifying Template

When the subject is correctly identified and near the displayed pose, then PAUSE the system. The update will use the current frame of data on the screen.

At this point the old Template ID feature is not working, but instead the generalized automatic Pose ID feature is looking to identify the unnamed markers. As soon as the ID is recognized and catches, you will see two stick figures; the static one from the Model Pose and one that is the newly ID-ed person that is moving. If the person is not ID-ed right away, have them face the same direction and assume the same general posture as seen in the Model Pose. The Auto ID feature works as long as the person is facing within about 45° of where the Model Pose was recorded.

The status display in the lower left tells you how fast the ID process took. A small number is a fast ID, a bigger number would be slower, but still working. Using the Reset IDs button on the lower right will force the software back to the Pose ID if something gets switched and you want to correct it.

Figure 6-21. Pose ID in Message Center and Reset IDs Button



PoseID: 11844 tests

Pose ID in Message Center **New Subject Button** **Reset IDs Button**

Updating the Template also updates the Model Pose, so before clicking the **Update Template** button, you should again get your new person into something close to the Pose position. The changes can be saved in your project file if you want.

After you Update the Template, the template is then re-sized to the new person's limb lengths and marker placements. Note that the changes in the lengths, as recorded in the range of motion trial is still saved, so that you will not need to do another range of motion. The new template should work well for many sizes and marker adjustments using the same marker set.

Recommended Procedure

1. Create your own library project file for the marker set. This library contains your markers set with the template created from your range of motion TRB files, and your Pose ID.
2. When creating the library project file, start with the range of motion TRB type file in the neutral position, facing +X, arms down, feet slightly apart to show all the markers. That would be frame 1 to make the Pose ID easy to find. When you create the Template for your library file, you would have Frame 1 selected as the current frame and you would check **Include Current Frame as Model Pose** for frame number 1. You should only need to do this once per marker set.
3. When the New Subject comes into the volume, they should be standing in the Pose position facing the same +X[1] and you select **New Subject...** The PoseID will show and you should then select **Pause**. The stick figure should snap to, looking like the Model Pose.

---

[1] Facing +Z or any other direction also works as long as Pose ID is used in the same orientation

4. Update the template, then select **Pause.** Check that the ID is correct and that the position is similar to the Pose. You can use the FIFO slider to make adjustments. Save the project file and then select **Run**.
5. Select **Update Template** again.

Using the Pose ID Feature

This feature allows the software to automatically identify markers based on a Model Pose that you create when you make a template. The result is that if you use the same marker set repeatedly, you will not have to ID the new person each time the marker set is used. The marker identification is automatic and instant, saving you time.

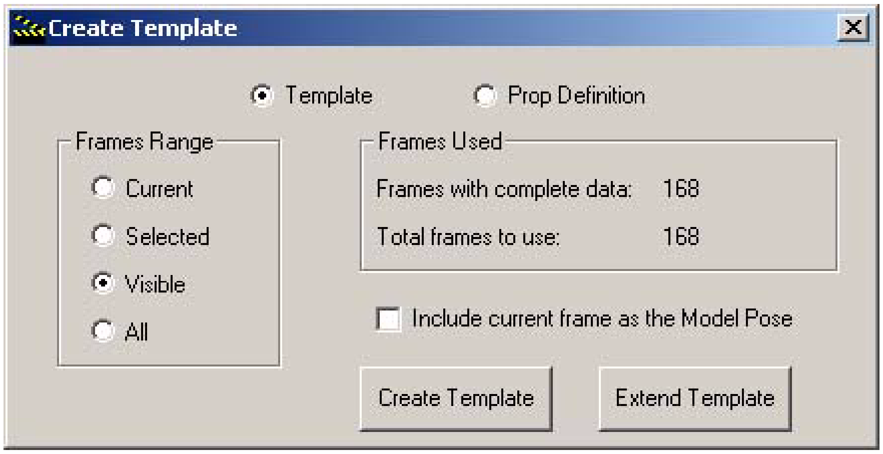
The Model Pose has its own kind of generalized template that is used to automatically identify a new person when they appear in the field of view. This generalized template depends on the person facing the same direction as the stored Pose ID and having the markers in the same general locations with respect to each other. You save the Pose ID from one frame of data and is saved in your project file. It saves you the steps of using the "Quick ID" feature to identify a new person in order to make a template for them. The Auto ID feature works in the RealTime mode when you are connected to cameras or it works when you are tracking the data from VC files after the collection.

The following are basic steps on how to use the Pose ID function.

Get a Range of Motion Trial and Make a Template

1. You will first want to obtain a good range of motion trial and set it as your current tracks in Post Process.
2. You will then need to Quick ID and edit the trial, if needed, so there are no mistakes or marker switches. It does not have to be overly complex, but it should represent the minimum and maximum stretching for all limbs. Jumping jacks is a good example of the kind of dynamic motion that has worked well and does not obscure the markers or require editing. For simple walking motion, a single walking trial will be sufficient.
3. Select one frame that represents a somewhat standard or neutral pose position. This can be with the arms down or the arms out, feet apart or together, but where no markers will be hidden. You want it to be a "standard" position that the next person will be able to repeat quickly and simply. Have the subject face a certain direction that will also be easily repeatable for the next person. (along the +X axis for example).

Figure 6-22. Create Template Interface



● Template ○ Prop Definition

Frames Range
○ Current
○ Selected
● Visible
○ All

Frames Used
Frames with complete data: 168
Total frames to use: 168

☐ Include current frame as the Model Pose

Create a Template

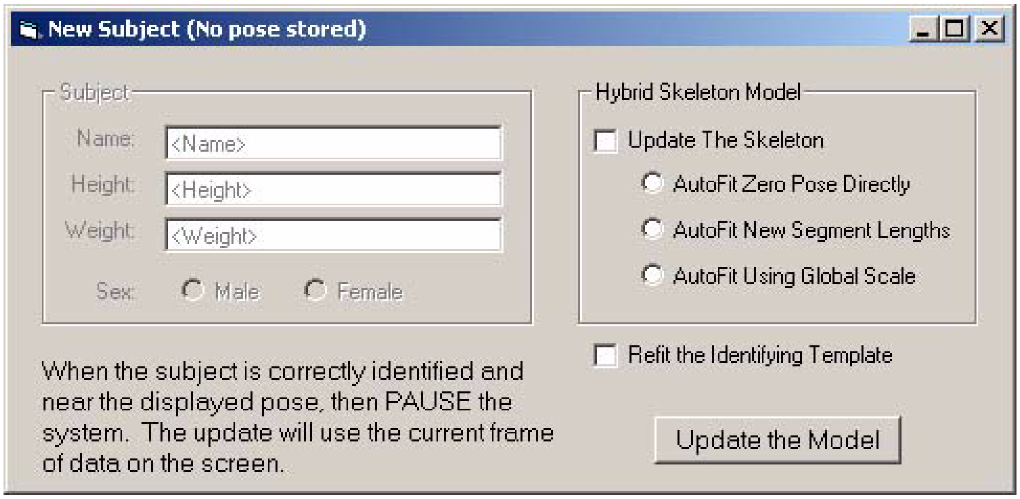
1. Select **Post Process > Create Template**.
2. Select **Body Template**.
3. Activate the **Include current frame as the Model Pose** check-box and select the correct range of frames where you have good data.
4. Save your project file which now has a new feature called Pose stored in it. You may want to use the word Pose in the project file name to distinguish it from earlier versions without the pose, but that is not necessary. The normal template will work for this person.

Getting Pose ID to Work: Tuning and Updating the Template

If the person who was used to create the template moves some markers or if a new person comes out with the same marker configuration (but in slightly different locations), you will want to update the template to the new marker locations. This will make sure that your RealTime tracking and the Template ID and Template Rectify functions in Post Process will be optimum. The steps are as follows:

1. Select **Motion Capture > Connect to Cameras** (or select VC files) and then select **New Subject…**. This will bring up the Pose ID dialog box and the Model Pose stick figure appears in the 3D Display.

Figure 6-23. Pose ID Dialog Box



New Subject (No pose stored)

Subject

Name: <Name>

Height: <Height>

Weight: <Weight>

Sex: ○ Male ○ Female

Hybrid Skeleton Model

☐ Update The Skeleton

○ AutoFit Zero Pose Directly

○ AutoFit New Segment Lengths

○ AutoFit Using Global Scale

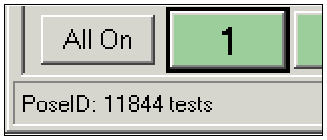
☐ Refit the Identifying Template

When the subject is correctly identified and near the displayed pose, then PAUSE the system. The update will use the current frame of data on the screen.

At this point the old Template ID feature is not working, but instead the generalized automatic Pose ID feature is looking to identify the unnamed markers. As soon as the ID is recognized and catches, you will see two stick figures, the static one from the Model Pose and one that is the newly ID-ed person that is moving. If the person is not ID-ed right away, have them face the same direction and assume the same general posture as seen in the Model Pose. It has been found that the Auto ID feature works as long as the person is facing within about ±45 degrees of where the Model Pose was recorded.

2. The status display in the lower left tells you how fast the ID process took. A small number is a fast ID, a bigger number would be slower, but still working. Using the Reset ID button on the lower right will force the software back to the Pose ID if something gets switched and you want to correct it.

Figure 6-24. Status Display



PoseID: 11844 tests

3. Updating the Template also updates the Model Pose, so before clicking the Update Template, you should again get your new person into something close to the Pose position. The changes can be saved in your project file.

4. After you have updated the template, the template is re-sized to the new person's limb lengths and marker placements, but the changes in the lengths, as recorded in the range of motion trial, is still kept. So you do not need to do another range of motion and the new template should work well for many sizes and marker adjustments using the same marker set.

Raw Video Button

The Raw Video button will tell the program to simulate a live motion capture session from previously captured Video Camera (VC) files. It also allows you to tack and record to TRB or TRC trials for which you have raw VC files.

Connect Cameras Button

The Connect Cameras button will activate all the cameras used in a motion capture session.

Run Button

The **Run** button will start the streaming of live camera data or start the simulation of a motion capture session from existing raw VC files.

The **Run** button has the following functions:

1. If you are connected to the cameras, it starts the data steaming from the cameras. You are able to record the Raw Video VC files as set in the motion capture Output sub-panel. Check your 2D views to be sure the cameras, masks, and thresholds are all set properly.
2. If **Enable Tracking** is checked, you will see the marker data appear in the 3D Display. This requires that the system has been calibrated. You are then able to record VC files, and TRC or TRB files.
3. If **Enable Identifying** is checked, you will see the colored markers and the stick figures in the 3D Display. This requires that the system is calibrated and a template is defined and operating. You are then able to record VC files, and TRB or TRC files.
4. Tracking from Raw Video files—If you are not connected to the cameras, you have the full range of option 2 or option 3 above from your previously collected Raw Video VC file.

Time Code Counter

The Time Code Counter displays the frame number in HH:MM:SS:Frame (hour, minute, second, frame) format. If you have the optional Time Code Reader card installed in your computer, this displays the current Time Code value when you are in the Motion Capture mode and connected to the cameras.

Frame Counter

The Frame Counter displays a count of the total number of frames in the data set.

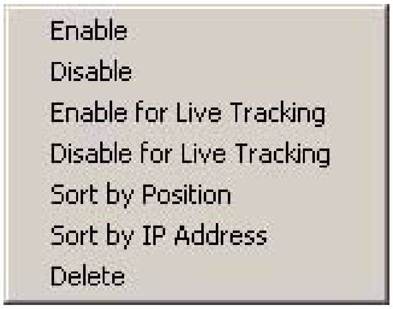
Camera Buttons

You can select each camera by clicking on it's respective numbered button that is listed across the Real Time Dashboard. Clicking on a camera button will either activate or de-activate that camera for setup features.

Right-Click Camera Buttons

Right-clicking on any of the camera buttons will open a function menu with various commands for that specific camera. The menu and a description of each command is shown in Figure 6-25.

Figure 6-25. Camera Buttons Right-Click Menu

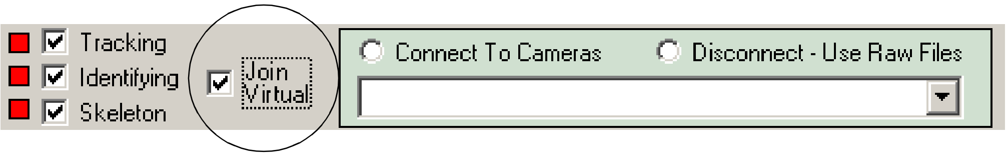


Enable	**Enables the selected camera to capture data (if disabled)**
Disable	**Disables the selected camera from capturing data**
Enable for Live Tracking	**Enables the camera to capture and display data in Real Time**
Disable for Live Tracking	**Disables the camera from data collection in Real Time only**
Sort by Position	**Camera numbers are sorted in a counter-clockwise order**
Sort by IP Address	**Camera numbers are sorted by IP address starting from lowest**
Delete	**Deletes the selected camera from the project file**

Join Virtual

Join Virtual is an extremely powerful editing tool used to fill gaps in marker data with simulated data based on the relationship (positional interpolation) with other markers on or near the particular problem segment. This positional interpolation is defined by Virtual Markers.

Figure 6-26. Join Virtual Check Box

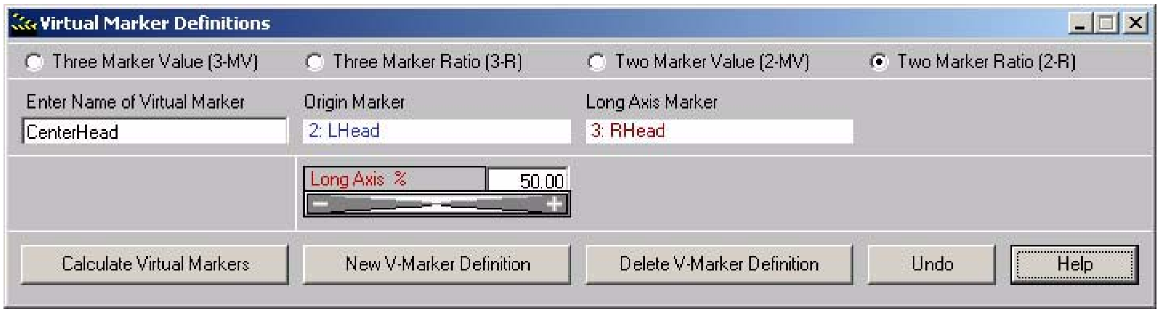

☑ Tracking
☑ Identifying
☑ Skeleton
☑ Join Virtual
○ Connect To Cameras
○ Disconnect - Use Raw Files

The concept behind the Join Virtual and the Virtual Marker definitions are the same and are much more stable and more useful than the classic Rigid Body data filling mechanisms. The reason is that you get to choose two sets of three markers, in decreasing importance, that determine the replacement data. These three markers are:

1. the Origin Marker
2. the Long Axis (Y) Marker
3. the Plane (XY) Marker

The two sets of virtual marker definitions allow you to continue generating virtual marker data if one of the definition markers is not being tracked. For the Join Virtual function to work properly, you will need a minimum of four different support markers among the six spots to fill. If you are in Streaming mode from cameras or VC files, the first definition set is used. If you are in Post Process mode, you may choose which definition set works best.

Figure 6-27. Virtual Marker Definitions


Virtual Marker Definitions
○ Three Marker Value (3-MV)
○ Three Marker Ratio (3-R)
○ Two Marker Value (2-MV)
Calculate Virtual Markers
New V-Marker Definition
Delete V-Marker Definition
Undo
Help

● Two Marker Ratio (2-R)

Enter Name of Virtual Marker: CenterHead

Origin Marker: 2: LHead

Long Axis Marker: 3: RHead

Long Axis %: 50.00

When running live, the Join Virtual tool only uses the first VM Join definition of the two that you are allowed. However, 4 passes are made over the list on each frame so that if a definition depends on another then after the first pass the second marker is reconstructed so that the first marker can be reconstructed on the second pass. It also works this way in Post Process mode when you have multiple markers selected and do a Join Virtual function.

Streaming vs. Post-Processing

The Real Time Join Virtual function (in the Real Time dashboard) eliminates what might be seen as a possible “pop” on the frame when the real marker re-appears. At that time, the Virtual Marker filling the gap is no longer used. This is the only solution for streaming (using the Join Virtual check box when you are recording the data either live or from raw video files).

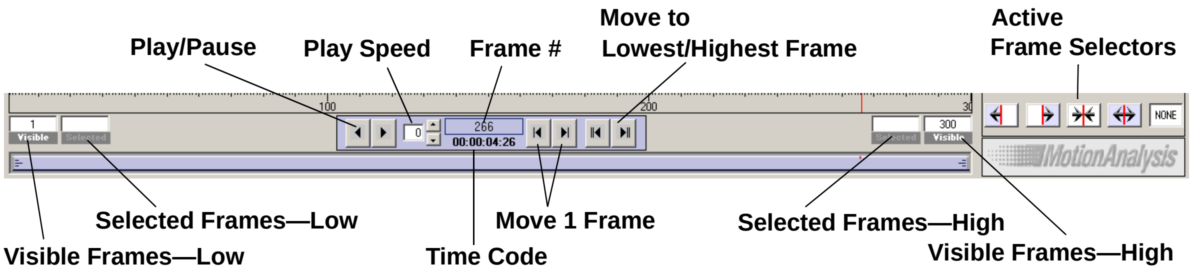
In the post-processing Join Virtual mechanism, the offsets between the marker to join and the Join Virtual Origin Marker are measured both at the start of the gap and the end of the gap, and a linear interpolation is used for all in between data points. The result is always a perfectly fluid transition on both ends of the gap.

The Join Virtual mechanism is a powerful tool in creating and editing data quickly with good results. It is the result of working with our customers to define and develop techniques to get good motion capture data quickly and efficiently.

Post Process Dashboard

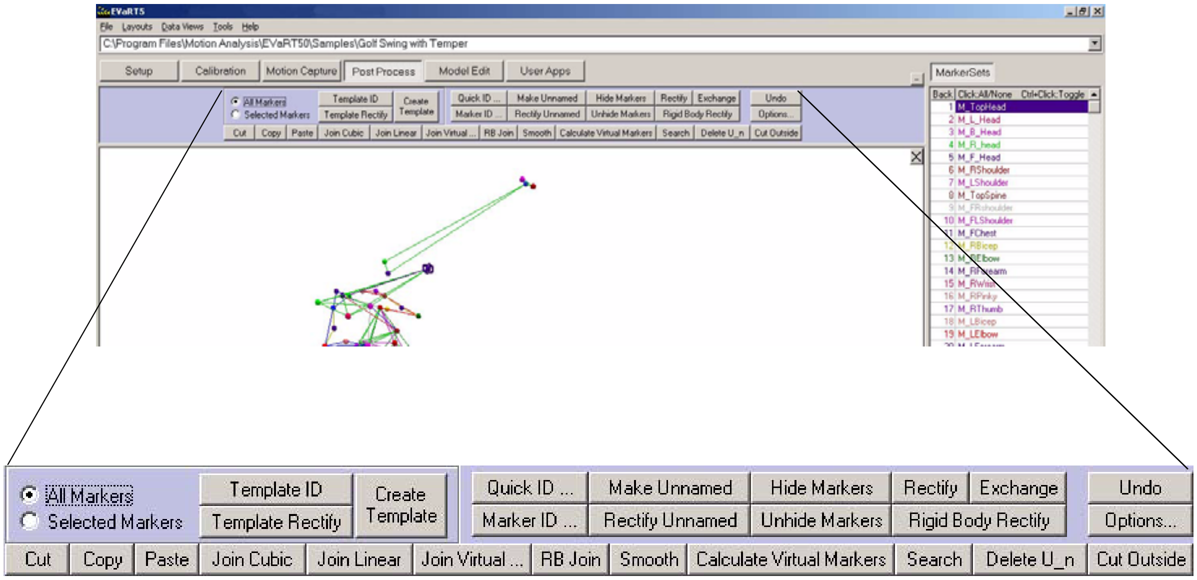
The Post Process Dashboard is available when **EVaRT** is in Post Process mode as opposed to Tracking mode. After you have generated and saved tracked data, this becomes available to help manage a data editing session. It controls the range of visible frames and the range of selected frames to be edited. It also provides several controls for playing through the tracked data and choosing a current frame. This dashboard is described further in Chapter 10, Post Processing Panel.

Figure 6-28. Post Process Dashboard


Play/Pause
Play Speed
Frame #
Move to Lowest/Highest Frame
Active Frame Selectors
100
200
30
1
Visible
Selected
0
266
00:00:04:26
Selected
300
Visible
NONE
MotionAnalysis
Selected Frames—Low
Visible Frames—Low
Time Code
Move 1 Frame
Selected Frames—High
Visible Frames—High

Post Process Toolbar

Figure 6-29. Post Process Toolbar


EVaRT5
File Layouts Data Views Tools Help
C:\Program Files\Motion Analysis\EVaRT50\Samples\Golf Swing with Temper
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
MarkerSets
Back Click:All/None Ctrl+Click:Toggle
1 M_TopHead
2 M_L_Head
3 M_B_Head
4 M_R_head
5 M_F_Head
6 M_RShoulder
7 M_LShoulder
8 M_TopSpine
9 M_FRshoulder
10 M_FLShoulder
11 M_FChest
12 M_RBicep
13 M_RElbow
14 M_RForearm
15 M_RWrist
16 M_RPinky
17 M_RThumb
18 M_LBicep
19 M_LElbow
● All Markers
○ Selected Markers
Template ID
Template Rectify
Create Template
Quick ID ...
Marker ID ...
Make Unnamed
Rectify Unnamed
Hide Markers
Unhide Markers
Rectify
Exchange
Rigid Body Rectify
Undo
Options...
Cut
Copy
Paste
Join Cubic
Join Linear
Join Virtual ...
RB Join
Smooth
Calculate Virtual Markers
Search
Delete U_n
Cut Outside

All of the Identifying tools are accessible using hot keys, panel buttons, and right mouse menu items on the 3D Display and XYZ Graphs.

All Markers Radial Button

Allows you to select all markers at once for Identifying.

Selected Markers Radial Button

Allows you to select specific markers for Identifying.

Template ID

Uses the template to ID all markers in the current frame.

Template Rectify

Uses the template and continuous tracks to ID markers thorough time.

Create Template

Refer to "Building a Template" on page 9-5.

Make Unnamed

Make Unnamed will specifically move a marker's data into the first unnamed marker slot. It is important to know that the data is not deleted by this operation.

Rectify Unnamed

Makes unnamed markers into contiguous paths to follow through the capture sequence. For more information on the Rectify functions, refer to "Rectify" on page 6-37.

Quick ID	Identifies the selected marker, identifying all markers one by one, according to the list. It will normally select with auto incrementation (Auto Increment).
Marker ID	Marker ID is the same as Quick ID, without the auto increment feature.
Exchange	Exchanges the XYZ coordinates of two selected markers.
Hide Markers	Hides selected 3D view markers.
Unhide Markers	Unhides the hidden selected 3D view markers.
Rectify	Re-identifies missing makers (gaps) in a determined frame range. For more information on the Rectify functions, refer to “Rectify” on page 6-37.

Rigid Body Rectify

Uses the selected markers to ID unnamed markers through the capture sequence. For more information on the Rectify functions, refer to “Rectify” on page 6-37.

Rigid Body Rectify and Template Rectify assume that all the current marker identifications are correct. They are intended for continuing the identification process without undoing previous work.

Rigid Body Rectify is a tool that could be considered a "stand-alone" tool. It does not use anything from the marker set definition at all. When the tool is activated:

1. The selected markers are dynamically turned into a "Rigid Body" definition and measured
2. The previous frame and the current frame are then used to predict the next frame
3. Identify the frame

This stops when less than three markers of the original selected markers is identified.

Note: If one or more markers are already correctly identified, then that can help prevent errors.

This has been used to identify the entire body.

1. Select ALL the markers (minus the obscured ones). The starting frame must be identified manually.
2. Press **Rigid Body Rectify**
3. Go forward to the frame where the misidentification occurred
4. Make unnamed
5. Repeat steps 2 through 5.

Options	Sets the sliders, zoom, and search options.

Rectify

Used for cleaning up the Initial Pose for making a template when you have no template to start with. Takes ALL markers on the current frame (regardless of the All vs. Selected radial button), measures the linkages on the current frame and uses those measures to automatically sort markers into the correct marker slots.

Characteristics of Rectify:

- Uses all markers, Named and Un-named
- Works only on the Highlighted XYZ Selected Time Range
- Uses the Named marker linkages and XYZ path continuity
- It will switch Named markers (Named markers are not automatically locked)
- Adjusts Linkage lengths dynamically to fit the data (including mistakes)
- Uses the **Motion Capture > Tracking > Identifying Parameters** function (typical)

Cut

Cuts the data within the selected frames inclusive of the endpoints.

Copy

Copies selected markers in selected frames.

Paste

Pastes data with the Current Frame being the first frame of the paste region.

Cut Outside

Cuts the data outside of the selected frames exclusive of the endpoints.

Smooth

Smooths data within the set frames with the selected filter type. The filter selection is found in the **Post Process > Options** form. For more information, refer to "Filters" on page 10-4.

Calculate Virtual Markers

This calculates the virtual markers based on the parameters set. For more information, refer to "Virtual Markers" on page 11-6.

Join Cubic

Calculates the values to place in the gaps with a cubic spline. If you manually select the endpoints of the gap before executing the join, the function will fill the gap with a linear interpolation because the second derivative at the endpoints equals zero.

Join Linear

Selecting this will automatically fill the gap with linearly interpolated data.

Join Virtual

For all information regarding Join Virtual, refer to See "Join Virtual" on page 6-33.

Exchange

Exchange requires that exactly two markers are selected. The data is exchanged between the markers within the selected frames.

Search

Finds gaps and/or spikes throughout the data set. The current frame will be set to the first gap or spike found in either the first selected marker on the marker list or all of the markers. See the Post Options form for settings.

Delete U_n

Deletes all unnamed markers.

Options

The Options button opens a form that lets you set the sliders, zoom, undo, and search (for gaps and/or spikes) options.

The Acceleration at Spikes function will indicate the frames in which a marker has experienced an acceleration greater than or equal to the selected value. The indicator appears as a carat (V) at the top of the XYZ Graphs.

The Memory Gauge lets you know when you computer is running out of memory to store edits in the undo buffer.

RB Join

The rigid body join feature has been created for rigid objects with 4 or more markers per segment. For rigid or semi-rigid objects such as swords, spears, head markers, torso markers, multiple markers on a basketball, it is convenient to use this feature to join across missing marker data. You must select a starting frame where all markers that you select are all present and part of a rigid body. You then select a range of frames on which you wish this to operate. Select **RB Join** and it automatically joins across the missing marker data.

Undo

Undo retrieves data affected by the most recent Edit or ID function and places it back into the data set. **EVaRT** supports ten levels of undo. This feature can be disabled or cleared on the Post Options form. If you get the message that an Undo function may not execute, you may need to clean your Undo buffer. This can be found in the **Post Process > Options > Undo** section.

Zooming, Rotating, and Translating

Zooming and translating a display can occur in both the 3D Display and the XYZ Graphs. Rotating only occurs in the 3D Display. Choosing **Help > Hot Keys and Tips** from the Menu Bar will bring up an online table describing how these features work.

Zoom—In the 3D Display, zooming is accomplished if you:

1. Hold the **Alt** key down.
2. Hold both the **left** mouse and **middle** mouse buttons down.
3. Move the mouse forward or left to zoom out and backward or right to zoom in.

Rotate—In the 3D Display, rotating is accomplished if you:

1. Hold the **Alt** key down.
2. Hold the **left** mouse button down.
3. Move the mouse in any direction.

Translate—In the 3D Display, translating is accomplished if you:

1. Hold the **Alt** key down.
2. Hold the **middle** mouse button down.
3. Move the mouse in any direction.

In the XYZ Graphs, time zooming is done in terms of frames (time) or amplitude. If you want to zoom in frames, there are two methods. 1) If one or no frames are selected, zooming is done relative to the current frame. 2) If two or more frames are selected, zooming is done relative to the selected frames.

Time Zoom Method 1

1. Click on the **Post Process** button among the Mode Buttons.
2. Press **F4** or choose **View > XYZ Graphs** from the Menu Bar.
3. Left-click on **None** in the lower right corner below the marker list. Now, no frames are selected.
4. Left-click anywhere on the XYZ Graphs to set the Current Frame which is indicated by the red line.
5. To zoom in, press the "Zoom Frames In" hot key (default is **I**) or by right-clicking in the XYZ Graphs and selecting "Zoom Frames In" from the pop-up menu.
6. To zoom out, press the "Zoom Frames Out" hot key (default is **O**) or by right-clicking in the XYZ Graphs window and selecting "Zoom Frames Out" from the pop-up menu.
7. Unzoom time: Double-click on the Time Slider on the Post Process Dashboard to zoom out completely making all frames visible. The Post Process Dashboard Visible boxes will now have a **1** and the highest frame number displayed.

Time Zoom Method 2

The second method of zooming in frames is described as follows:

1. Hold the **middle** mouse button down in the XYZ or the Analog Graphs.
2. Drag the mouse to the right or left to select any number of frames.
3. To zoom in, press the "Zoom Frames In" Hot Key (default is I) or by right-clicking in the XYZ Graphs window and selecting "Zoom Frames In" from the pop-up menu.

Amplitude Zoom

Zooming amplitude is done relative to the closest data point and frame nearest to the location you initially click on. You can optionally zoom into the data in the Current Frame regardless of where your mouse cursor is on the screen. This option is a User Preference and it can be set by launching the Options Form from the Post Process panel.

1. Hold the **Alt** key down.
2. Hold both the **left** mouse and **middle** mouse buttons down.
3. Move the mouse forward and backward.

In the XYZ Graphs, translating is accomplished if you:

1. Hold the **Alt** key down.
2. Hold the **middle** mouse button down.
3. Move the mouse in any direction.

Selecting Markers, Virtual Markers, Linkages, and Segments

Markers can be selected by the following:

1. Clicking on the markers seen on the 3D Display
2. Double-clicking on the markers seen in the XYZ Graphs
3. Clicking on the markers listed on the Marker Grids (which are a part of the Post Process panel, the Model Edit > Markers sub-panel, and the Model Edit Tree View)

Note: All of the conventional **Shift** + click and **Ctrl** + click techniques to select multiple items are supported in this software.

Time Code

SMPTE Time Code and EVaRT Overview

SMPTE Code reads as HH:MM:SS:FF, which is Hours:Minutes:Seconds:Frame. Frame numbers are 0 to 29 in NTSC and 0 to 24 in PAL. When you capture at a higher motion capture rate such as 60 or 120 Hz, there are multiple motion capture VC frames per color video frame. The software takes care of that so if you record your VC files at 60 Hz, the VC frame advances twice for every single frame advance in the color video when you play it back or step through the data. The SMPTE time code is visible on the Real Time Dashboard.

Using the Time Code Reader Option with Eagle and Hawk Cameras

Eagle and Hawk digital cameras can use the Time Code Reader (PCI version) card, installed into the **EVaRT** Host computer. It reads the LTC (Longitudinal Time Code) from the RCA audio connector on the Time Code card, creating a **trialN.tc** file (time code) when you collect a **trialN.vcX** dataset. It is automatic if you have the Time Code Reader option (card) installed in your **EVaRT** computer. There is a BNC type connector on the card as well; it appears that the Time Code Reader will genlock to the black burst video signal, but that is not needed. **EVaRT** reads the current time code when the data collection is started and time stamps it into the TC file. The current time code also displays on the Post-Process Dashboard.

A simple test program called **TimeCodeReader.exe** is distributed with the latest **EVaRT** releases for Eagle and Hawk camera users. It is a standalone program which launches, and in a small window reads the current value of the Time Code Reader in the **EVaRT** Host computer. It is useful for testing to see if the Time Code reader is working. Without a card installed, it just leaves a blank display. With a time code reader card installed, it displays the current time code, static or not. When the time code starts to advance, you can immediately see it.

Using the Time Code Reader Option with Non Eagle and Hawk Cameras

On Midas-based systems, the Time Code Reader card is an ISA type card that plugs into the NT Midas box. On the **EVa 6.0** and **7.0** CD, there is a folder under **RTMIDAS** called **DOCS** which has information about turning ON and OFF the Time Code reader option. See **TimeCode_Notes.doc**. This feature is not supported on older DOS Midas systems. When it is turned on, a TC file is created in the capture folder as with the Eagle and Hawk option above. There is a sample program for NT Midas systems that reads and displays the time code. It can be found in this EVaRT release distribution CD in the **Tools\RTmidas** folder with the name of **MACTCReader.exe**.

Using the Time Code in Post Processing

If you load a TRB or TRC file that has an associated TC file, then the Post-Processing Dashboard will lock the time code onto the time code display. You can step forward or backwards in time or push the play button and the time code reads accurately. If you switch back to the Motion Capture panel and are connected to the cameras, you will see the current time code. If you are in the Motion Capture panel and are not connected to the cameras, but using Raw Video Files, you will see the Time Code associated with the Raw Video File.

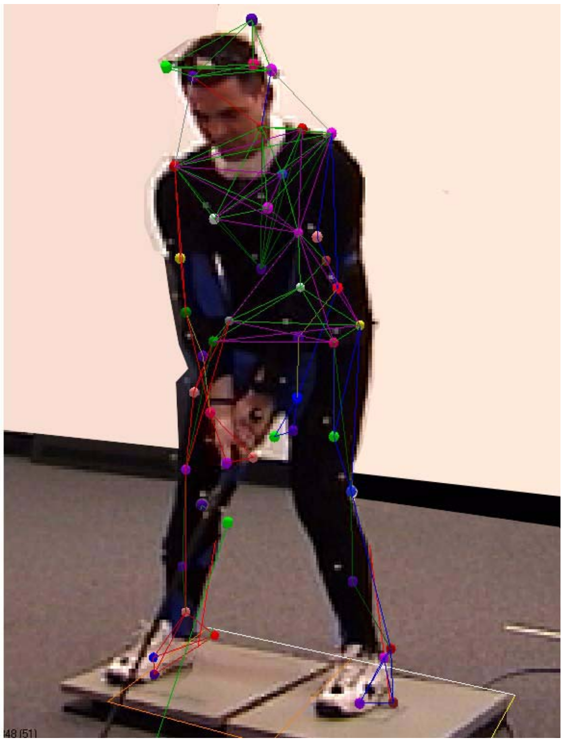
Time Code and the Digital Video (EVaDV) Option

The Digital Video option can be used with the Time Code. In our current software, the only way to record the time code is with the Time Code Reader card. Some cameras have Time Code capability within the camera, but those time codes are not recorded with the DV (Digital Video) option. The Time Code must be connected to the Time Code Reader card to have a TC file created and hence be time coded.

Live Video Backdrop

The Live Video Backdrop allows you to set your streaming live video as the backdrop to your 3D display. To activate this function, right-click in the 3D display and select **Show Video**.

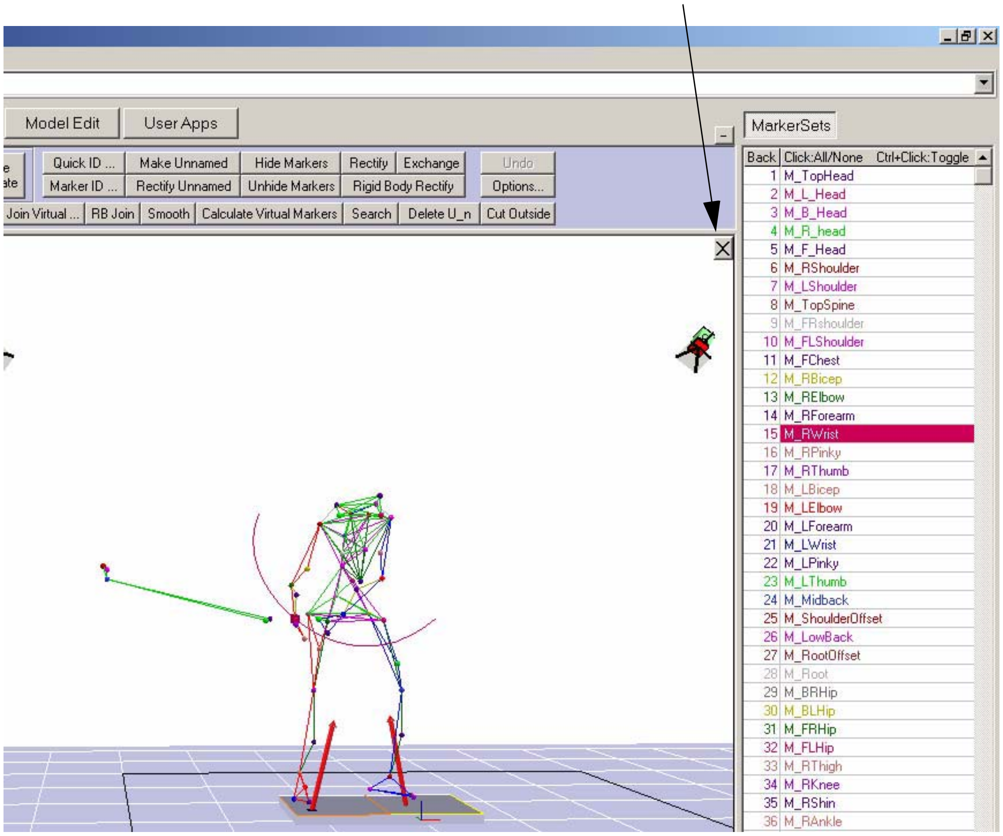
Figure 6-30. Live Video Backdrop



Unload Tracks Button

This button provides a quick method to unload, or not save any changes to, the Tracks files which you have edited.

Figure 6-31. Unload Tracks Button


Unload Tracks Button
Model Edit
User Apps
MarkerSets
Quick ID ...
Make Unnamed
Hide Markers
Rectify
Exchange
Undo
Marker ID ...
Rectify Unnamed
Unhide Markers
Rigid Body Rectify
Options...
Join Virtual ...
RB Join
Smooth
Calculate Virtual Markers
Search
Delete U_n
Cut Outside
Back
Click:All/None
Ctrl+Click:Toggle
1 M_TopHead
2 M_L_Head
3 M_B_Head
4 M_R_head
5 M_F_Head
6 M_RShoulder
7 M_LShoulder
8 M_TopSpine
9 M_FRshoulder
10 M_FLShoulder
11 M_FChest
12 M_RBicep
13 M_RElbow
14 M_RForearm
15 M_RWrist
16 M_RPinky
17 M_RThumb
18 M_LBicep
19 M_LElbow
20 M_LForearm
21 M_LWrist
22 M_LPinky
23 M_LThumb
24 M_Midback
25 M_ShoulderOffset
26 M_LowBack
27 M_RootOffset
28 M_Root
29 M_BRHip
30 M_BLHip
31 M_FRHip
32 M_FLHip
33 M_RThigh
34 M_RKnee
35 M_RShin
36 M_RAnkle

Chapter 7

Setup Panel

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Creating and Clearing Masks	7-12
Going Live	7-12
Adjusting Thresholds	7-12
Analog Sub-Panel	7-13
Misc Sub-Panel	7-16

Getting Started

Before using **EVaRT**, you must configure your software to match the overall system. Setup Mode provides tools to do this. The camera settings do not need to be reset before each and every motion capture session but they do need to be reset after changes are made to the cameras.

1. Choose **File > Load Project...** from the Menu Bar and load a recent or sample project.
2. Choose **Setup** from the Mode Buttons.
3. Choose the Cameras sub-panel from the panel buttons if it is not already open.
4. Select the correct camera type from the Camera Type drop down list. Change the camera type and frame rate to correspond to your hardware and the desired frame rate.
5. Leave the Sub-sampling Rate set to the default for normal data collection.
6. Click **Connect to Cameras** on the Real Time Dashboard if your cameras and connections are fully operational.

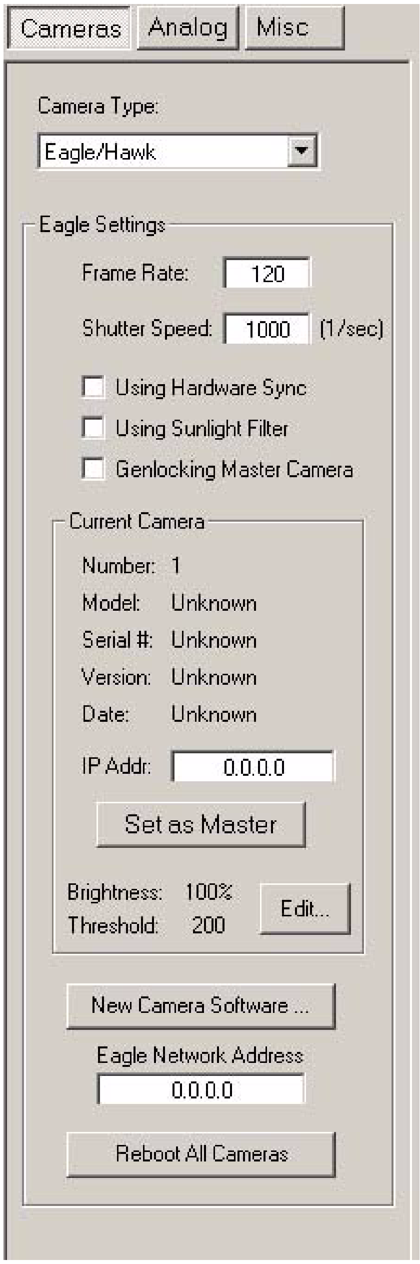
The system is now ready to go live with the **Run** button.

Cameras Sub-Panel

Eagle/Hawk Camera Settings

To view the settings mentioned in this section, you must have the Camera Type set to **Eagle/Hawk** and you must have the **[Eagle Support]** item in your **mac_lic.dat** file.

Figure 7-1. Cameras Sub-Panel


Cameras
Analog
Misc
Eagle Settings
Current Camera
Set as Master
Edit...
New Camera Software ...
Reboot All Cameras

Camera Type: Eagle/Hawk

Frame Rate: 120

Shutter Speed: 1000 (1/sec)

☐ Using Hardware Sync

☐ Using Sunlight Filter

☐ Genlocking Master Camera

Number: 1

Model: Unknown

Serial #: Unknown

Version: Unknown

Date: Unknown

IP Addr: 0.0.0.0

Brightness: 100%

Threshold: 200

Eagle Network Address: 0.0.0.0

Frame Rate

Sets the frame rate of the Eagle digital camera to any number ranging from 0.1 to the maximum frame rate. The number does not have to be an integer; it may be set to 59.05, for example.

Note: The maximum supported frame rate for the Eagle digital camera system is 500 Hz. Please contact Motion Analysis Customer Support for information and technical advice for using frame rates higher than 500 Hz.

Shutter Speed

Sets the shutter speed of the Eagle digital camera ranging from 0 to 2000µs. This pulse is issued is in conjunction with the timing of the strobe (ring light) pulse. There are 1024 different levels of shutter speed control.

Using Hardware Sync

This is selected when you are capturing data at high frame rates (greater than 500 Hz) and the cameras are wired together with the Hardware Sync cable

Using Sunlight Filter

When activated, this feature eliminates large blobs (targets) and one-pixel blobs in the camera hardware caused by typical outside lighting. The tracking parameter “Max Horizontal Lines per Marker” gets set as the max size allowable target in horizontal pixels.

Genlocking Master Camera

This is selected when the master camera is synced to an external video source, either NTSC or PAL To enable the feature, you must have a license feature installed in your mac_lic.dat license file that looks something like the following line:

```
[Eagle Genlock]     9c3856f6    782cb125
```

Please contact support@motionanalysis.com if you need this item.

To turn it ON, check the box called **Genlocking Master Camera** in the **Setup > Cameras** sub-panel. When this is done, the Master Camera (which can be any of your Eagle, Eagle-i, Hawk or hawk-i cameras) must have an analog video signal (black burst or other signal) applied to the camera. This is done using the BNC connector of the 2 meter long Eagle Test Cable that came with the Motion Analysis system. It connects to the master camera using the AUX connector on the back of all the MAC digital cameras. Failure to connect the video signal to the Master camera will show up when you press the Run button. The slave cameras will send data but the Master camera will not.

This feature is available on all Motion Analysis digital cameras and can be set to any multiple of the NTSC or PAL frequencies that your mocap camera will allow. So you can capture at 59.94 (NTSC frequency) or 119.88 (2X NTSC) or 179.82 (3X NTSC) or higher if your motion capture camera will allow it. For Eagle/Eagle-i cameras and NTSC genlock sync, you need to set the camera frame rate to 59.94 Hz (on the Cameras sup-panel). For PAL genlock sync, set the camera frame rate to 50 Hz (or 100 or 150 or 200 or so on). The slave cameras will follow the master camera without any extra wiring.

Brightness

Sets the brightness of the ring lights for all cameras.

Current Camera Information

Displays the selected camera number and its corresponding IP address, software version number, along with the date and time the Eagle software was compiled.

Changing the Camera's IP Address

You can change the IP address in this box for any camera at any time. You need to make sure that you do not use duplicate numbers though. It is recommended that you use the same IP address number scheme as used when the cameras are first shipped (10.1.1.xxx). The last three digits should be any number between 1 and 250. In the event that your local area network is set to a 10.1.1.xxx IP scheme, you can also use 10.1.2.xxx for the Eagle camera network (Eagle Host computer, EagleHubs, Eagle cameras, etc.).

Set as Master

Sets the selected camera as a master camera. A master camera generates synchronized pulses to the rest of the cameras within the system so that all camera shutters are opening and closing at the same rate.

Note: Only one master camera can be set for each system.

The master camera is set as follows:

1. In the Real Time Dashboard, select the camera number button of the camera which you would like to set as a master camera.
2. Click on the **Set Master Camera** button.
3. If the camera is not turned on or working, select another camera in the Real Time Dashboard, and then press **Set Master Camera** again.
4. If you have an analog sub-system, the A-D sync cable must be connected from the master camera to the A-D Interconnect box. See Figure B-3 on page B-6.

Any camera may be designated as a master camera, but only one at a time.

Loading New Camera Software...

This allows you to select and upload new software, when available, into the selected camera.

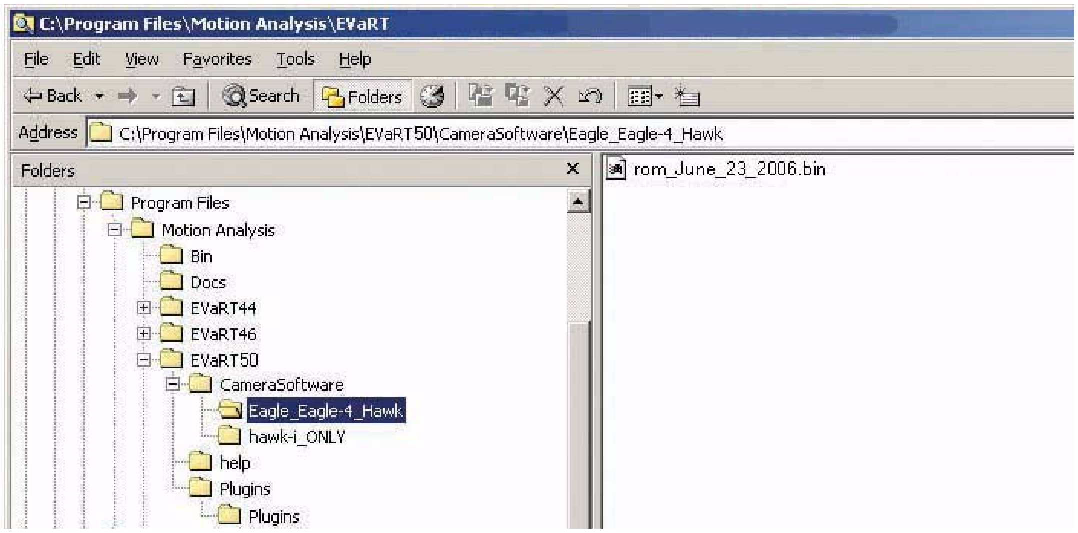
Note: The software loaded into the camera must be of the form **rom_date.bin**. The specific date in the file name may vary.

Note: Hawk-i cameras require a different version of the **rom.bin** software from the other digital cameras. Loading of incorrect software may cause your Hawk-i camera to cease functioning. The **rom.bin** file for the Hawk-i cameras is found in a folder of its own, under the Camera Software directory.

To ensure of the latest software release, the **rom.bin** file will have the date and time of the program in the file name (e.g. **rom_Jun_23_2006.bin**). Install the new software as follows:

1. Obtain the latest **rom_(date).bin** file from Motion Analysis Corporation by means of either an FTP site, e-mail, or disk.
2. Copy the **rom_(date).bin** file into the following directory: **C:\Program Files\Motion Analysis\EVaRT50\Camera Software**

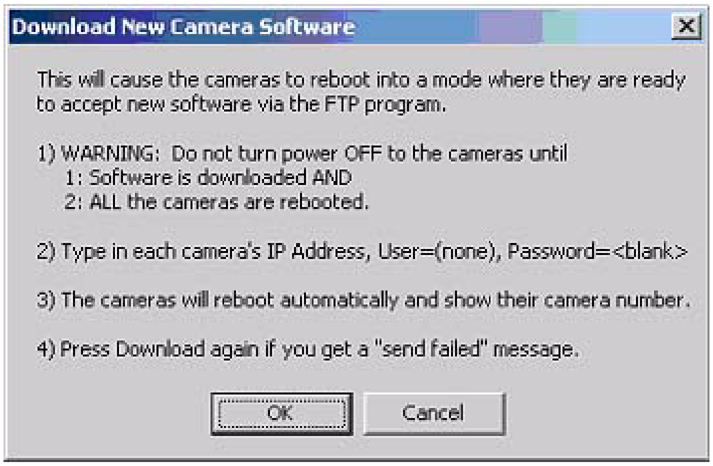
Figure 7-2. Camera Software Directory


C:\Program Files\Motion Analysis\EVaRT
File
Edit
View
Favorites
Tools
Help
Back
Search
Folders
Folders
Program Files
Motion Analysis
Bin
Docs
EVaRT44
EVaRT46
EVaRT50
CameraSoftware
Eagle_Eagle-4_Hawk
hawk-i_ONLY
help
Plugins
Plugins
rom_June_23_2006.bin

Address C:\Program Files\Motion Analysis\EVaRT50\CameraSoftware\Eagle_Eagle-4_Hawk

3. Return to the Calibration sub-panel in the **EVaRT** user interface.
4. Select the camera (on the Real Time Dashboard) you wish to load the new **rom_(date).bin** software into and click on the **New Camera Software...** button in the Cameras sub-panel.

Figure 7-3. Download New Camera Software Verification Dialog



Download New Camera Software

This will cause the cameras to reboot into a mode where they are ready to accept new software via the FTP program.

1) WARNING: Do not turn power OFF to the cameras until
   1: Software is downloaded AND
   2: ALL the cameras are rebooted.

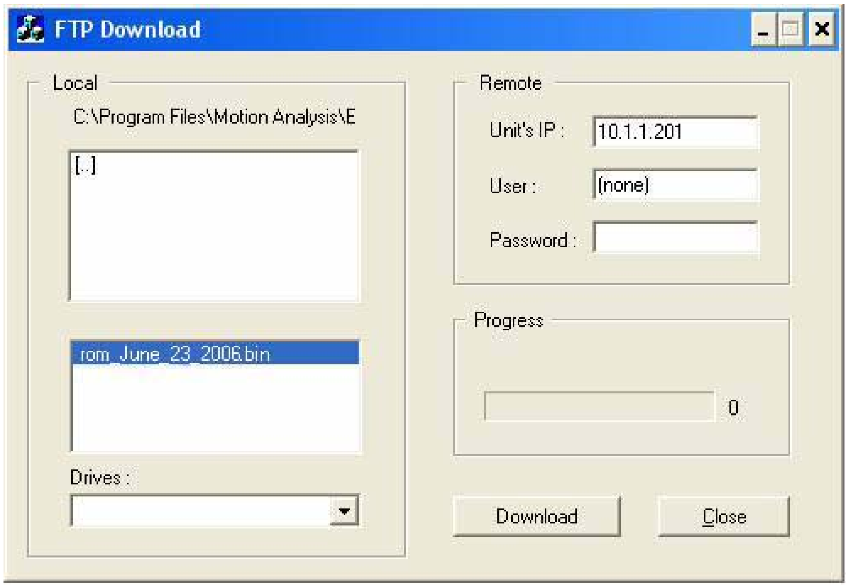
2) Type in each camera's IP Address, User=(none), Password=<blank>

3) The cameras will reboot automatically and show their camera number.

4) Press Download again if you get a "send failed" message.

5. Manually type in the Unit's IP address prior to clicking on the **Download** button.
6. Navigate to the **Camera Software** directory with the **[..]** and select **rom_(date).bin**.

Figure 7-4. New Camera Software Interface, Loading the rom.bin File



Local: C:\Program Files\Motion Analysis\E

[..]

rom_June_23_2006.bin

Unit's IP : 10.1.1.201

User : (none)

Password :

7. Click **Download** and wait about two minutes for the Writing to Flash operation to finish.

Note: If the message "Send Failed" appears, ignore and press **Download** again.

8. Once the software has been loaded, the cameras may blink oddly. After this, you will need to reboot all the cameras by cycling the power on the EagleHub.
9. Run the **EVaRT** software and click on **Connect to Cameras**.
10. Finally, check all cameras for the new software version number.

Note: For Eagle and Hawk Camera users, the camera software with this release is:

\CameraSoftware\Eagle_Eagle 4_Hawk\rom_June_23_2006.bin

For hawk-i camera users, the camera software is:

\CameraSoftware\hawk-i_ONLY\rom_Hawki_June_23_2006.bin

Do I need to update camera software?

You can continue to use the Eagle or Eagle-4 or Hawk **rom_May09_2005.bin** or later software. Reasons to upgrade to the new camera software include:

1. Genlock to multiples of NTSC or PAL video
2. Hardware sync for Eagle cameras and frame rates above 500 Hz
3. Mixed camera environment with hawk-i cameras

Old Camera, New Camera Compatibility Issues

Cameras with different revisions of the CPU board installed may exhibit problems with different versions of the rom.bin software.

How to tell which cameras have the OLD CPU board and which cameras have the NEW CPU Board is easy:

- ALL MAC DIGITAL Cameras with the SILVER backplate (where the connectors are) have the newer CPU boards (CE approved) and require the newer camera software, dated **May 9, 2005** or later.
- Cameras with the BLACK backplate have the older CPU card (non CE approved) can use either the NEWER or the OLDER rom.bin software.

The **rom_Mar_11_2004** software was released with the **EVaRT 4.2** software.

The **rom_May_9_2005.bin** software was released with the **EVaRT 4.4** software

Dedicated Interface for Eagle Cameras

Allows you to input the IP address for the network interface card (NIC) of the host computer. This is the IP address for the NIC that is connected to the Eagle cameras. There must be a dedicated NIC for this purpose. Other connections to local area networks (LAN) must be done on a different NIC to avoid network traffic on the Eagle camera network and to keep the Eagle system working properly.

Reboot All Cameras

Reboots the cameras (cycles the power). This is used when changing the camera's IP addresses. Note that the camera and software will not recognize the change in IP address until the camera has been rebooted.

Falcon and Other Camera Settings

Note that if you change the camera type in this sub-panel, you will need to perform a new calibration, both square and wand. Changing the sub-sampling rate does not affect the system calibration.

Sub-sampling Rate

The Sub-sampling Rate is the actual rate of raw data collection. Frames may be skipped over during the data collection if the sampling rate does not match the hardware rate.

Video Display Options

The Video Display Options will affect the image displayed on the Falcon Threshold Monitor.

Show Video

Shows the grey scale video image direct from a camera (for analog cameras only).

Show Threshold

Shows a black and white binary image indicating those picture areas above and below the specified video threshold level (for analog cameras only)

Show and Use Masks

Shows the masks or areas designated to receive no marker information.

Eagle and Hawk Camera Display Codes

The Eagle and Hawk digital camera displays indicate which mode the cameras are operating. Note that hawk-i and eagle-i cameras do not have the display feature.

Table 7-1. Eagle and Hawk Camera Display Codes

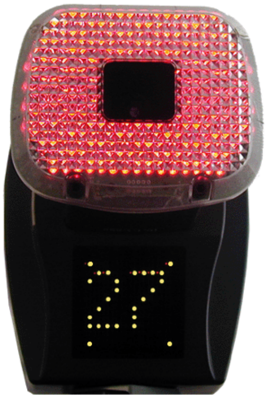
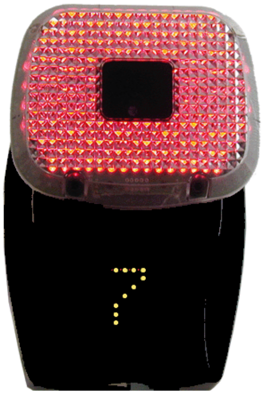
Code	Image	Description
Master Camera		This display code, with the active LEDs in the four corners, indicates that the camera has been set as a master camera. The ringlights are ON, which indicates that **Connect To Cameras** on the **EVaRT** interface is active. Yellow (Red and Green ON) numbering indicates that the camera is in an idle state (powered up but not connected). Red number displays indicate that the camera is either disabled, out of sync, or that there is a hardware problem within the camera.
Standard Camera		This display code has no active LEDs other than those set for the number display LEDs. This indicates a standard operating camera.

Table 7-1. Eagle and Hawk Camera Display Codes

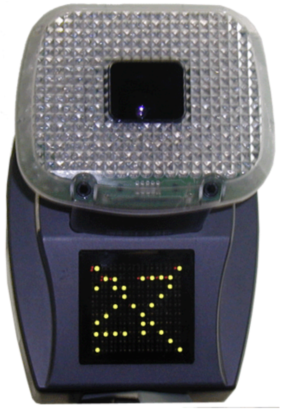
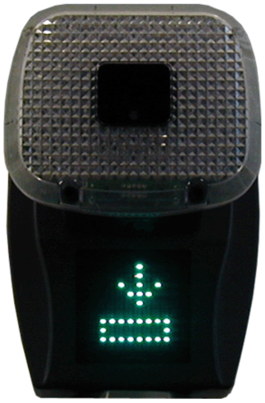
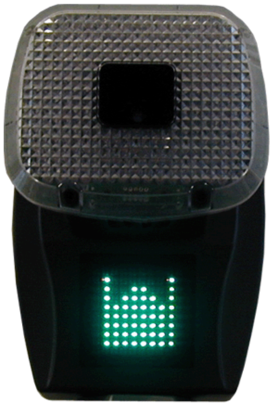
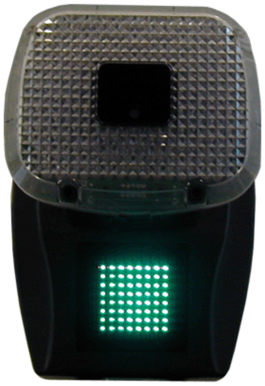
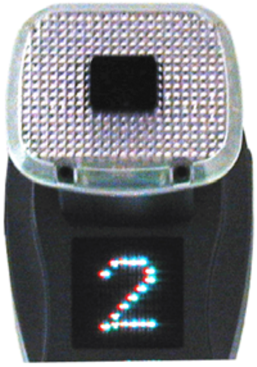
Code	Image	Description
Camera Ready for rom.bin Download		This display code, with the active LEDs in a slash through the display number, indicates that the Eagle camera is ready to accept a new **rom_date.bin** file. This display code will be go away after the new software has been installed and the camera is rebooted.
Press Download		This display code, with active LEDs in an arrow and rectangle pattern, indicate that the Download button, in the Download FTP window, is ready to be pressed.
Rom.bin Download in Progress		This display code indicates the progress of the download process. The number of activated LEDs will increase as the download process nears completion.

Table 7-1. Eagle and Hawk Camera Display Codes

Code	Image	Description
Rom.bin Download is Complete		
Camera ON, not Connected to EVaRT		This display code, with both green and red LEDs activated for the number display, indicates that the camera has been powered ON, but is not connected to **EVaRT**.

Creating and Clearing Masks

Masks are rectangular regions that you designate to receive no marker information. Masks allow you to block out fixed light sources that cannot be physically removed from a camera’s view. Masks are created on the 2D Display by clicking and dragging the middle mouse button and appear as hatched regions.

Masks can be cleared by using the right mouse pop-up menu item in the 2D Display and choosing either **Delete Mask** or **Delete All Masks**. Note that you can use masks after the VC data has been collected by disconnecting from the cameras, creating the mask, and then loading or selecting the raw files. This applies to the calibration files (CalSeed and CalWand) as well.

Going Live

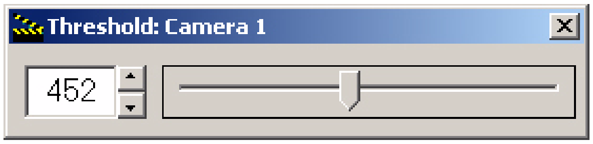
After having configured the software to the system and connected **EVaRT** to the cameras:

1. Place the Calibration Square on the floor in the capture volume. The orientation of the Calibration Square determines the directions of your global X, Y, and Z axes.
2. Press **F2** on the keyboard to open the 2D Display. The view seen by one or several cameras will be displayed. To select multiple cameras, press **Shift** + click or **Ctrl** + click on any of the camera buttons on the Real Time Dashboard or click **All On**.
3. Click the **Run** button on the Real Time Dashboard.

Adjusting Thresholds

1. Choose **Tools > Edit Thresholds...** from the Menu Bar.
2. Slide the Threshold slider on the floating Thresholds control until the markers on the floor appear on the screen.

Figure 7-5. Threshold Slider



3. Select a camera.
4. If you are not seeing any blobs on the screen, choose **Motion Capture** from the Mode Buttons. Then in the Tracking Panel, set the Min. Horizontal Lines per Marker to **2** and Max Horizontal Lines per Marker to **100**.

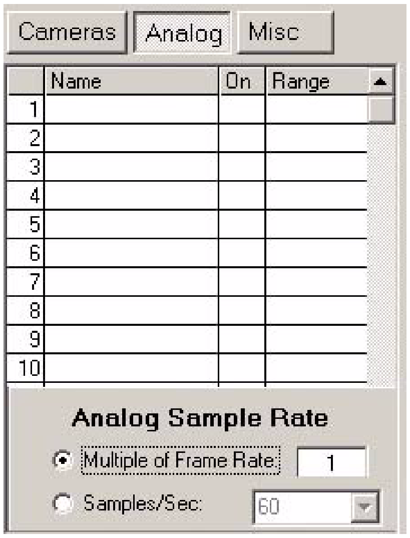
5. Mask out any unwanted light sources by creating a mask with the middle mouse button held down. Delete masks by clicking on a mask and pressing **Delete** on the keyboard or right-clicking in the 2D Display and selecting **Delete Mask**.
6. Repeat Steps 4 through 5 for all cameras.

Analog Sub-Panel

For users who have integrated force plates into their motion capture system, you will need to configure the EMG or other analog source signals for the analog signals to be collected properly. This is done by following these steps.

1. Choose **Setup** from the mode buttons.
2. Choose **Analog** from the sub-panel buttons.

Figure 7-6. Analog Setup Grid



	Name	On	Range
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Analog Sample Rate

● Multiple of Frame Rate: 1

○ Samples/Sec: 60

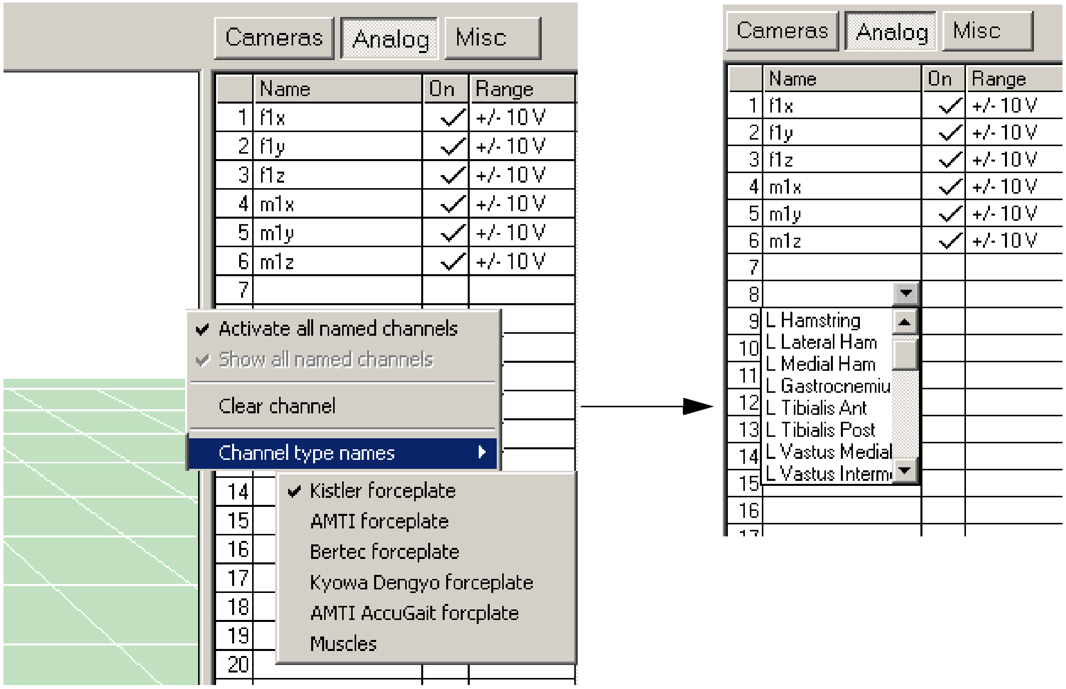
Note: In general, a multiple of the frame rate is recommended. For longer captures (more than 5 seconds), this is required.

3. To open a list of force plate names, right-click anywhere on the Analog sub-panel grid and choose **Channel Type Names** from the pop-up menu. The built in names include Kistler, AMTI, Bertec and Muscles.
4. To edit a channel’s name, left-click in its row in the Name column.
5. Left-click on the arrow that appears in the cell and select a name. Alternatively, you can simply left-click in the cell and type in a name directly.

6. Left-click in the channel's row in the Active column if you wish to make it active. You can also click in the Active column's title cell or right-click on the Analog sub-panel grid and select **Activate All Named Channels**. Both actions activate all named channels.
7. Left-click in the channel's row in the Range column and click on the arrow to select a voltage range. The range must match the output of your analog device.
8. Select the correct sample rate for your system from the Sample per Second drop list at the bottom of the panel.
9. To select EMG muscle names, right-click in the Analog sub-panel and select **Channel Type Names > Muscles.** For any particular analog channel number, left-click in the Name column and scroll through the drop-down menu for the EMG muscle name you want (see Figure 7-7).

Note: The Forceplate and EMG muscle names are consistent with the names used in the **Orthotrak** Gait Analysis and KinTrak software from Motion Analysis.

Figure 7-7. EMG Muscle Name Selection


Cameras
Analog
Misc
✓ Activate all named channels
✓ Show all named channels
Clear channel
Channel type names
✓ Kistler forceplate
AMTI forceplate
Bertec forceplate
Kyowa Dengyo forceplate
AMTI AccuGait forcplate
Muscles
L Hamstring
L Lateral Ham
L Medial Ham
L Gastrocnemiu
L Tibialis Ant
L Tibialis Post
L Vastus Medial
L Vastus Interm

	Name	On	Range
1	f1x	✓	+/- 10 V
2	f1y	✓	+/- 10 V
3	f1z	✓	+/- 10 V
4	m1x	✓	+/- 10 V
5	m1y	✓	+/- 10 V
6	m1z	✓	+/- 10 V
7			

10. To save the entries in the Analog sub-panel, choose **File > Save Project** from the Menu Bar.
11. If you would like to give the file a new name or save it to a different directory, choose **File > Save Project As...**.

Shifting Selected Analog Data

This series of functions is used to correct the time-shift-delay in certain telemetered EMG channels. These are introduced by Noraxon EMG units (model 2400 and later), which have a 15ms delay in their signal transmission protocols. As a result, the EMG signals in multi-source (EMG and Forceplates) analog data collected by the Motion Analysis system become non-synchronous with the motion data.

EVaRT allows the user to time shift the EMG data in the analog channels using the following steps:

1. Load a Project File
2. Load a Tracks file (.trb/.trc).
3. Select **Data Views > Analog Display**.
4. In the Analog Display window, right click and select the Visible Channels option.
5. In the Analog Display window, right-click and select the **Shift the Data** option.
6. In the Visible Channels dialog, select only the channels you want shifted (typically the EMG data).
7. In the Shift the Data dialog, select the **Selected Channels** option.
8. Set the value for the “Shift the data this number of samples”. This can be calculated by the following formula:

   # of samples to shift = (Analog Sample Rate) x (Time Delay)

Example

For an analog sampling rate of 1200 samples/second and a time delay of 15 ms (15 x 10^{-3} seconds) the calculation would be:

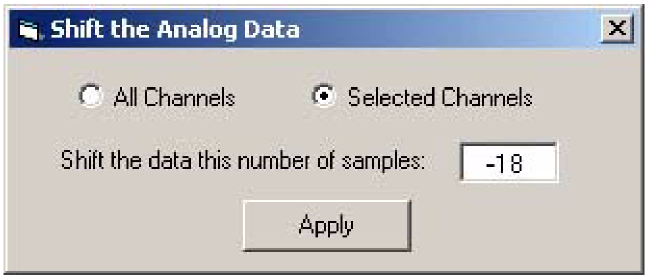
# of samples to shift = (1200 samples/sec) x (15 x 10^{-3} sec) = 18 samples

1. To input this frame shift correctly, enter the number as negative value (–18).

   Negative values indicate a shift to the left (decreasing the delay), positive numbers indicate a shift to the right (increasing the delay).

2. To change the entered value from red to black, press **Enter**.
3. Click on **Apply**. When it prompts you with "Would you like to rewrite the analog file?", select **Yes**.

Figure 7-8. Shift the Analog Data Dialog Box



○ All Channels ● Selected Channels

Shift the data this number of samples: -18

Misc Sub-Panel

The Misc sub-panel (Figure 7-10) provides additional setup options and functions that are in development stages.

From Raw Video Files (Options)

CPU Speed

Processes files as fast as the CPU will go.This is a feature when you are not connected to the cameras, but you are using Raw Files. If you click on the Run button (which causes the program to perform all the checked functions: Track, Identify, Skeleton), the difference is that CPU speed will go as fast as possible, which means if you have a fast enough computer, it is done is less time than the capture time.

Real Time

Slows down the software to pause between frames if there is available time. If you select Real Time speed, it will wait between frames (and update the display) so that the motion being tracked is not faster than real-time playback. If the time to process the data is slower than realtime (lots of markers, fast frame rate), then the selection does not matter (it tries to keep up with real time, but there is not enough time). When you are Connected to Cameras, the CPU Speed setting does not matter.

Loop Raw File

Loops the file to continuously repeat in Run mode. Note that if you record to a trb file with this feature ON, the trb file will contain all of the loops as well.

Skeleton Engine

No Skeleton Calculation

Turns off any skeleton calculations for the Motion Capture and Post Processing panels.

Skeleton Builder (SkB)

Turns on the skeleton builder definitions (if present in the project file) and allows the skeleton to be calculated. To see the skeleton in the Motion Capture or Post Processing panels, you must have the Show Skeleton feature turned on in the 3D window (right-click in the 3D display and select). All **EVaRT** users can calculate the **SkB** skeletons after they have been defined, but creating and editing skeletons requires a separate software license.

Fill in SkB Gaps

If the markers for a bone segment disappear, the position information for that segment is automatically filled in based on its previously measured position in relation to its parent. This is helpful in live performance situations to help make the animated character's motion appear more smooth when the markers that define the segment disappear.

Calcium Solver 1.2.10 (or later)

Checking this option tells the software to use the Calcium Solver type skeleton. The version number of that software is listed after its name and it can be loaded independently with a different **solver.dll**. You must have the Show Skeleton feature turned on in the 3D window and you must have clicked the Calculate Skeleton "Bone Button" in Post Processing to have the skeleton calculated. Note that **SkB** skeletons are calculated automatically in Post Processing, but you must press the Big Bone button to calculate the Calcium Solver skeleton. To calculate the skeleton, you must also have a model file (the .mod file) of the same name as the project file in your current directory. Model files are created and edited in the **Si 2.0/ Calcium** software. Any user can run and calculate the Calcium Solver skeletons, but it takes a separate license to edit and create the model files. The skeleton can be calculated in the Motion Capture panel from either live camera data or in the simulated realtime mode when you "Disconnect -Use Raw Files".

SIMM OrthoTrak Model

This skeleton calculation uses the Calcium Solver type skeleton and requires that you use the anatomically named marker set defined in the **OrthoTrak** software. The **OrthoTrak SIMM** basic marker set uses fixed names like L.Shoulder, L.Wrist, and L.Knee for prominent marker locations. There are several required markers and many more optional markers. If you use this marker set, you do not need to use the **Si/Calcium** software for creating a model (.mod) file. You must also use an additional "Static" trial with inside (medial) knee and ankle markers. You load the Static project file, load the Static Trial, click this **SIMM OrthoTrak** button and then the Big Bone (calculate skeleton) button becomes active. Then load the Walking (motion) trial and click the **Big Bone** button on the Post Processing screen. The Calcium Solver skeleton is calculated. To see the skeleton in the 3D window, select **Show Skeleton**. The skeleton can be calculated in the Motion Capture panel from either live camera data or in the simulated realtime mode when you "Disconnect -Use Raw Files".

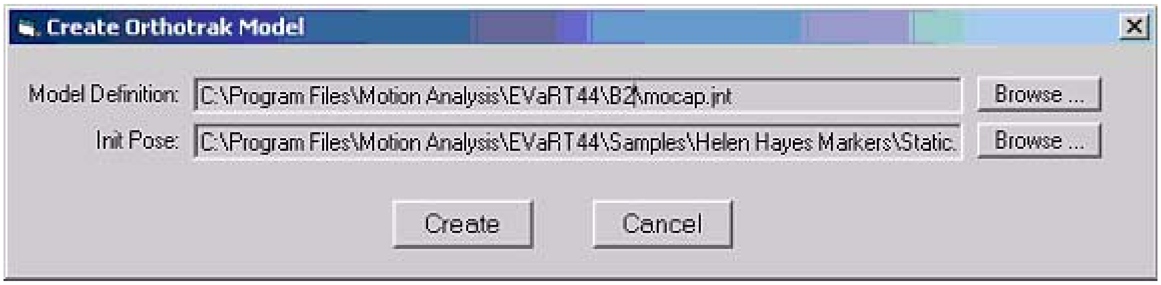
Create Orthotrak Model

The Create OrthoTrak Model button brings up the dialog box as shown in Figure 7-9. It uses a pre-defined SIMM model, which is pre-defined in a .jnt file and is generally part of the **EVaRT** software release. It also uses the current Tracks file with the Static + Dynamic markers to create a scaled model of the person with the correct bone lengths. This allows the user to calculate the Skeleton with the Post-Processing Calcium Bone button or in the Motion Capture mode in real time. The skeleton engine that is used is the very high-quality Calcium skeleton engine which iteratively fits the "marker cloud" of named markers around the pre-defined skeleton structure using a least mean squares, "global optimization" method. The joints are pre-defined in the SIMM-type .jnt file and modification of this file requires detailed knowledge of the SIMM (Software for Interactive Musculoskeletal Modeling) software. The steps for calculating a new OrthoTrak-SIMM model are as follows:

1. Select **File > Load Project** with all marker names used in the DYNAMIC or Walking trials.
2. Select **File > Load Tracks file** with all DYNAMIC markers.
3. Select **Setup > Misc > Skeleton Engine** and click-on the button **Create OrthoTrak Model...**
4. Select **Model Definition** and browse to the correct .jnt file. The OrthoTrak marker set uses the mocap.jnt file (the default). Jack uses the Jack.jnt file. Note that it is easiest if you put copy the .jnt file to the folder where your **EVaRT** executable resides and you will not need to navigate to another folder.

5. Select **Init Pose**. Browse to the .trb file where you have all of the Static + Dynamic markers. For the OrthoTrak model, this is the trial with both legs with the medial ankle and knee markers applied. For the Jack software there is only one marker set for both static and dynamic trials. Use the standing Init trial with the legs together facing the +X direction, arms out, elbows bent at 90 degrees, thumbs pointing towards each other. Click-on **Create**. This creates the scaled model with the correct bone lengths for this person and saves this in a .jnt file with the same name as your project name in your current data folder. In the future, if you load the project file, the associated .jnt file also gets loaded. If there is a personal.dat file in the folder with the init pose file, Solver will read it when scaling the model. Hip center offsets, ankle and knee diameters, and foot lengths are read from this file, if they are present.
6. In the Post Process panel, in bottom left corner you now have the Calcium Bone button. Clicking on this button solves the skeletal segments for your walking trial with the correctly scaled bone lengths for this person. At this point, you can use the 3D window right-click Show Menu to show or un-show: Skeleton, Skin and Skeleton Axes. Also, the **File > Export HTR** function allows you to save the segmental data into an HTR file.
7. For additional Dynamic Trials of the same person, select **File->Load Tracks file with DYNAMIC markers**. Note that the Bone button still remains in the bottom-left corner of the **EVaRT** interface. Press the Bone button and a correctly scaled Skeleton gets created. At this point, you can go to **File > Export HTR** and you will have a file with the segmental data. Also, you can use the 3D window right-click Show Menu to show or un-show Skeleton, Skin and Skeleton Axes. Note, that this IS the way you have to run the create skeleton option. Once you have done the 'Create OrthoTrak Model' step, you can run a real time capture with a skeleton being generated on the fly. Also, if you save the project file in step 3, you can Load the project file with Dynamic trials and start at step 5 above. Also, after you have create the OrthoTrak model, you can check the box in the Motion Capture mode **Calculate Skeleton** and the skeleton will be calculated in real time when you are Connected to Cameras or Disconnected and using VC files to simulate real time performance. It takes more CPU resources to calculate these, so pay attention to the **Task Manager > Performance** tab to see if your computer is fast enough.

Figure 7-9. Create OrthoTrak Model Dialog



Create Orthotrak Model

Model Definition: C:\Program Files\Motion Analysis\EVaRT44\B2\mocap.jnt

Init Pose: C:\Program Files\Motion Analysis\EVaRT44\Samples\Helen Hayes Markers\Static.

Model Definition: A SIMM defined JNT file must be selected. The **mocap.jnt** file is the one used for the OrthoTrak marker set. Other joint files exist for special applications, such as specific ergonomic models.

Init Pose: Select the static trial that applies additional medial markers to help define the joint centers. This is the static trial in the OrthoTrak marker set and sometimes called the Init Pose with the animation software packages.

Other Misc Sub-Panel Functions

Disable Sound Effects

This turns the sound features of **EVaRT** on and off.

Load Another Tracks File

This merges another track trial into memory so you can view two different data trials in the 3D window. A Frame Offset lets you offset in time the merged data. Only positive offsets are allowed. It is meant for visualization of multiple data sets in the 3D window. The first trial that is loaded must have enough frames to wholly accommodate the additional trials as additional memory for any additional frames is not allocated and can cause unpredictable results. You can make one trial that has enough frames to fully accommodate all of the merged data frames and load that track data set first with the **File > Load Tracks** menu item. The merged data does not get marker names or linkages unless you have a project and marker sets defined for the additional tracks.

Frame Offset

This offsets the first tracks file with respect to the second. The first tracks file loaded must have enough frames to accommodate all additional tracks files. If not, unpredictable results may occur. This is intended for viewing multiple trials. To see the stick figures, multiple marker sets must exist in your current marker set.

Number of Marker Slots

This function depicts the number of marker slots the software will use. **EVaRT** allocates memory based on this number. Earlier releases of **EVaRT** would require a Heavy Duty version for a large number of marker slots. This latest version will variably assign memory according to the number of marker slots used. The maximum number of marker slots that **EVaRT** will allow is 1500. The default number of marker slots is set to

192, which uses 512 MBytes of memory. From 193 to 500 markers, the amount of memory used is 750 MBytes. From 501 to 1500 markers, the amount of memory used is 1000 MBytes.

Note: Upon changing the number of marker slots, you must relaunch **EVaRT**.

Forceplates—Force Vector Scale

This adjusts the scaling factor of the force vector that is deployed in the 3-D display.

Forceplates—Autozero Forces

When active, this check-box automatically zeros all named forceplate channels. This does not affect the raw data in the .anb files. This does affect the following:

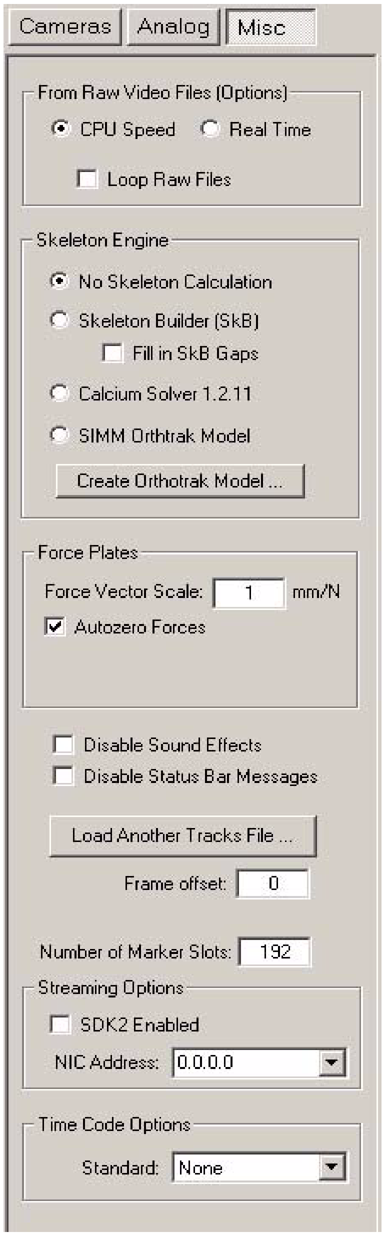
1. Force Vector Display in the 3D window
2. **File > Export Force File** function
3. **Tools > Show Forceplate Forces** function

This works when connected to the cameras and uses the first analog sample to set the zero value. This is set when the user selects Run or Record. In Post-Processing, it uses the first analog sample of each forceplate channel in the .anb file to set the zero values.

Streaming Options

This option streams all motion capture and post process playing data to the NIC address specified. This must be a NIC (Ethernet) address of the **EVaRT** host computer. If there are multiple NIC cards in the host computer, you must indicate which card will be used to stream the SDK2.

Figure 7-10. Misc Sub-Panel


Cameras
Analog
Misc

From Raw Video Files (Options)
● CPU Speed ○ Real Time
☐ Loop Raw Files

Skeleton Engine
● No Skeleton Calculation
○ Skeleton Builder (SkB)
☐ Fill in SkB Gaps
○ Calcium Solver 1.2.11
○ SIMM Orthtrak Model

Create Orthotrak Model ...

Force Plates
Force Vector Scale: 1 mm/N
☑ Autozero Forces

☐ Disable Sound Effects
☐ Disable Status Bar Messages

Load Another Tracks File ...

Frame offset: 0

Number of Marker Slots: 192

Streaming Options
☐ SDK2 Enabled
NIC Address: 0.0.0.0

Time Code Options
Standard: None

Chapter 8 Calibration Panel

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What is the Square and Wand Calibration?	8-2
Calibration Sub-Panel	8-3
Calibration Files	8-13
Refine Sub-Panel	8-15
Calibration from Previously Collected Files	8-18
Tips for Getting More Accurate Data	8-18
Extending the Seed Calibration	8-19
Post Processing Square and Wand Data	8-22

Calibrating Your System

A new calibration must be performed whenever:

- camera positions have changed
- the coordinate system orientation has changed
- the units of measure have changed
- you have changed the camera setup for your Falcon camera (Eagle and Hawk cameras do not require recalibration when you change the frame rate.)

It is imperative to complete an accurate calibration in order to collect high quality motion data.

Calibrating your system is a two step process. First, the seed calibration is done by employing the Calibration Square. The exact positions of these markers must be known. Next, a wand with precisely located markers is waved around throughout the capture volume by somebody wearing no reflective material. Wand calibration ensures that a direct measurement of an object of known size has been made by all cameras throughout the entire capture volume.

This process locates the exact positions of your cameras and accounts for any geometric distortion the camera lenses may have, as well as accurately measuring the camera lens focal-lengths. The importance of this information is so great that a new calibration must be completed if a camera is moved or even accidentally bumped.

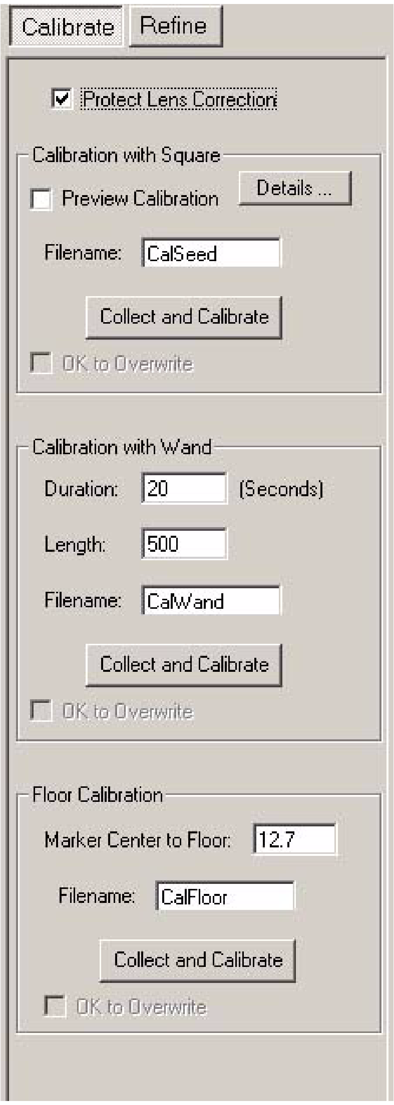
What is the Square and Wand Calibration?

In **EVaRT**, a four-point square and wand calibration takes the place of the cube and wand calibration that was done in previous versions of **EVa** software. This method has proven to be very robust and is extremely accurate. This method requires only four markers and the wand.

Note: If using an L-frame, orient your markers in the same directions as illustrated. Care should also be taken in placing the 4 points on the floor as this determines the global axes and the orientation of the volume displayed in **EVaRT**. The points on the 3-point axis must be in a straight line and the spacing of point 2 must be close to 1/3 of the distance between points 1 and 3.

Calibration Sub-Panel

Figure 8-1. Calibration > Calibrate


Calibrate
Refine
Calibration with Square
Details ...
Collect and Calibrate
Calibration with Wand
Collect and Calibrate
Floor Calibration
Collect and Calibrate

☑ Protect Lens Correction

☐ Preview Calibration
Filename: CalSeed
☐ OK to Overwrite

Duration: 20 (Seconds)
Length: 500
Filename: CalWand
☐ OK to Overwrite

Marker Center to Floor: 12.7
Filename: CalFloor
☐ OK to Overwrite

Protect Lens Correction

This locks the lens corrections coefficients for all cameras as saved in your project file. Once you have set your lenses’ focus and zoom factor, the lens distortion maps should not change and they need not be calculated with each wand calibration. With **Protect Lens Correction** checked, the wand calibration will converge more quickly. So if you do not change the lenses, it is a good idea to leave this box checked for all your calibrations AFTER you have completed a good wand coverage and good wand calibration. The results of the successful wand calibration are stored in your project file and your System Calibration file. The System Calibration file can be saved after each wand calibration. It is the default calibration that is used when your launch the **EVaRT** software.

For a very accurate calibration, do the following steps:

1. Uncheck **Protect Lens Correction**.
2. Collect a very thorough wand calibration making sure to cover the corners of all the cameras. Uncheck **Heavily Weighted Seed** and then select **Run Again** until the numbers stop changing. Accept the results.
3. Check **Protect Lens Correction**.
4. Disconnect from cameras. Select the **WandCal.vc1** file and press the **Calibrate > Calibration > Calibration with Wand Calibrate** button AGAIN. Let it run once, un-check **Heavily Weighted Seed** and press **Run Again** until the numbers stop changing, then Accept the results.

The above procedure uses the first Wand Calibration to determine the Lens Distortion mappings and uses the second processing of the Wand calibration to refine the calibration. Subsequent wand calibrations can be run like steps 3 and 4 if you do not change the lens settings.

Details... Button (Calibration Settings Window Tabs)

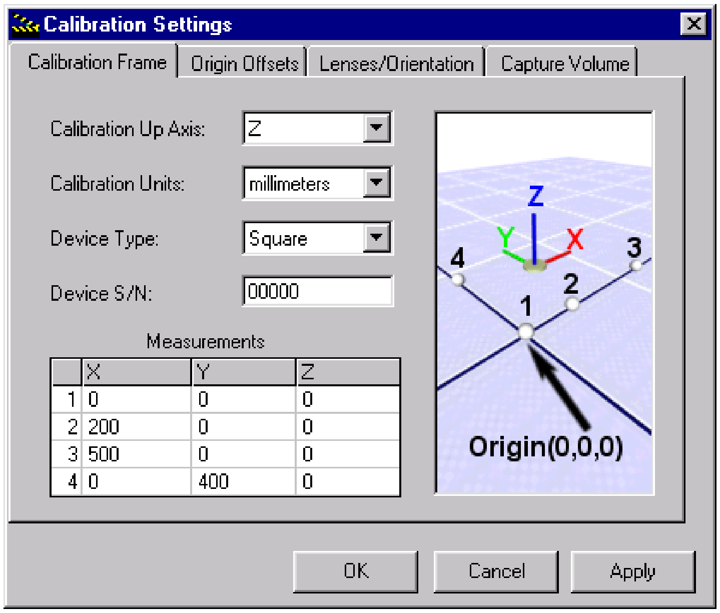
Click the **Details** button, located in the upper-right corner, in the Calibration sub-panel.

The tabs for the calibration settings window, shown in Figure 8-2 on page 8-5, are defined as follows.

Calibration Frame

Where you enter the measurements of the Calibration Square. You can make your own Calibration Square by placing four markers on the floor and measuring their locations with a tape measure. Measurements should be within 1 mm. See Figure 8-2 for reference alignment using the Z-up calibration method. Selecting a different calibration up-axis will show the correct view on how to set up your calibration square.

Figure 8-2. Calibration Frame Tab



Calibration Settings

Calibration Frame
Origin Offsets
Lenses/Orientation
Capture Volume

Calibration Up Axis: Z

Calibration Units: millimeters

Device Type: Square

Device S/N: 00000

Measurements

	X	Y	Z
1	0	0	0
2	200	0	0
3	500	0	0
4	0	400	0

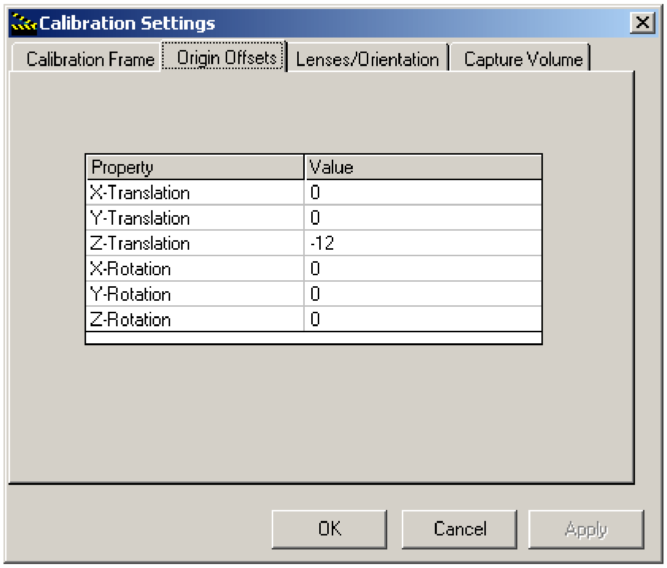
Z
Y
X
4
3
2
1
Origin(0,0,0)
OK
Cancel
Apply

Origin Offsets

This allows for translation and rotation from the origin. The Calibration Square may then be positioned anywhere in the motion capture area. This is useful for two possible reasons:

1. All cameras do not see the calibration frame, but you want to use it to position the cameras. In this case, you can move the calibration frame to where it can be seen and enter the Origin Offsets measured from the true origin to the (temporary) location of the calibration frame.
2. You want a different location for an origin for any reason.

Figure 8-3. Origin Offsets Tab


Calibration Settings
Calibration Frame
Origin Offsets
Lenses/Orientation
Capture Volume
OK
Cancel
Apply

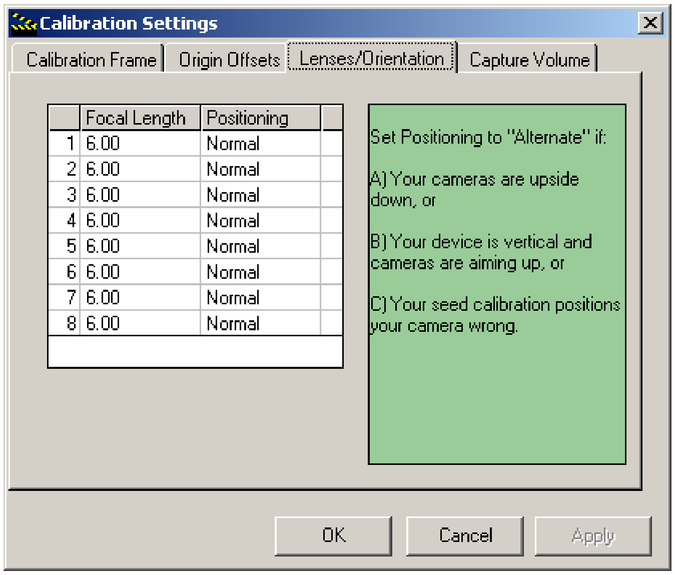
Property	Value
X-Translation	0
Y-Translation	0
Z-Translation	-12
X-Rotation	0
Y-Rotation	0
Z-Rotation	0

Lenses/Orientation

This indicates the focal length and positions of each camera as used in the **Collect Calibration Square** button. If you use the **Preview Calibration** check box to position and orient your camera, the focal length entries should be nominally correct (e.g. 6 for 6 mm lenses). In the Preview Calibration and Calibration with Square functions, the **Show > Show Camera Field of View** cone is determined only by what you put in this table. After the wand calibration, the actual focal length of the lens is calculated exactly and can be stored in your project file.

Note: The **Calibrate Wand** option calculates the actual focal lengths, but does not update the table.

Figure 8-4. Lenses/Orientation Tab



	Focal Length	Positioning
1	6.00	Normal
2	6.00	Normal
3	6.00	Normal
4	6.00	Normal
5	6.00	Normal
6	6.00	Normal
7	6.00	Normal
8	6.00	Normal

Set Positioning to "Alternate" if:

A) Your cameras are upside down, or

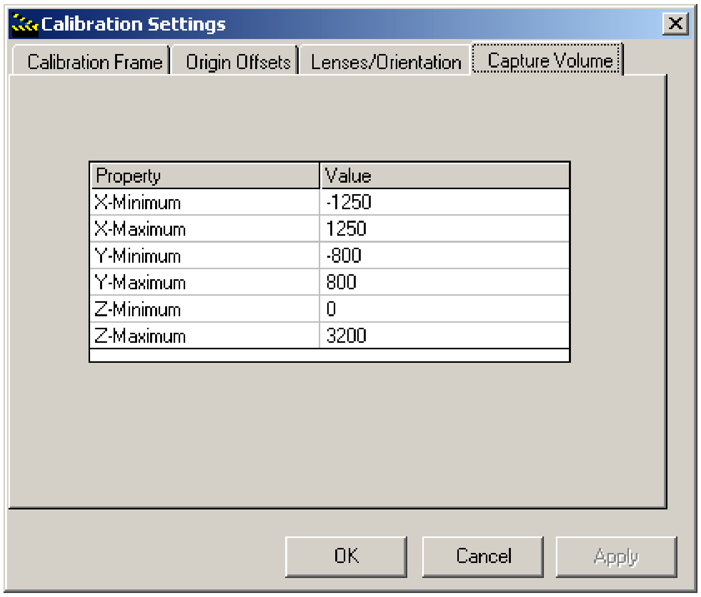
B) Your device is vertical and cameras are aiming up, or

C) Your seed calibration positions your camera wrong.

Capture Volume

This displays the rectangular capture volume according to your measurements and helps to provide a visual reference of the volume to the operator. It does not affect the tracked data in any manner. It is for display purposes only.

Figure 8-5. Capture Volume Tab



Property	Value
X-Minimum	-1250
X-Maximum	1250
Y-Minimum	-800
Y-Maximum	800
Z-Minimum	0
Z-Maximum	3200

Square (Seed) Calibration of Cameras

Select **Calibration > Details,** and a **Calibrations Settings** window pops up as shown in Figure 8-2. The Calibration Square should be laid out on the floor exactly as is in this figure. This can be done with four separate loose markers, or it can be done using the wand and a single loose marker, placed at the end of the wand handle. The distances from the origin are measured and are entered into the **Measurements** spaces. Observe the right-hand rule and make sure that you enter the data correctly. In the Z-Up example in Figure 8-2, points 1, 2, and 3 would be at +X, and point 4 would be at +Y coordinates, but adjust accordingly to your Calibration Up Axis. The vertical distances are the distance from the center of the markers (centroid) to the floor. Click on the other tabs and fill in the values accordingly. The Lenses tab should reflect the type of lenses you have in your camera (e.g. 6 mm, 17 mm, 20 mm etc.). The values for the lenses need only be approximations within a factor of two. The actual focal lengths are calculated when you process the wand data. Once you have completed filling in the details, press **Apply** and return to the Calibration window in **EVaRT**.

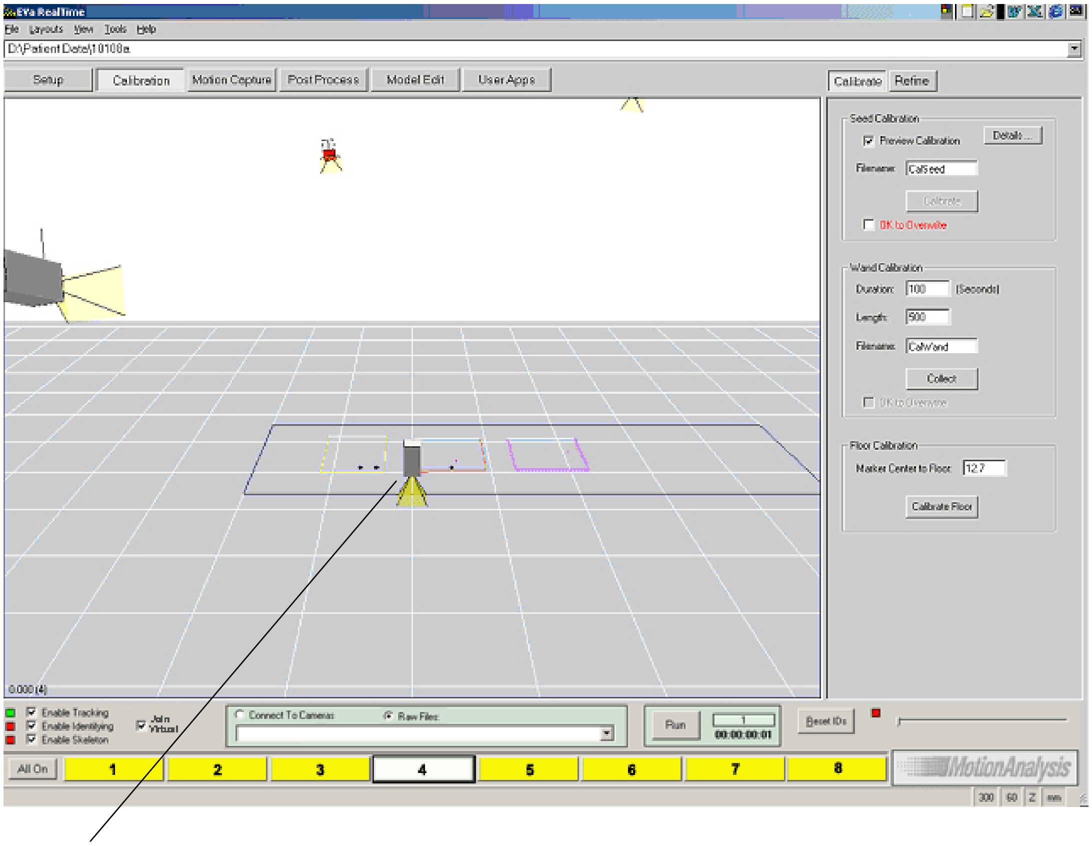
Using Preview Calibration to Position or Aim Your Camera

Select **Calibration > Calibrate Box**, check **Preview Calibration** and then press **Run**. The cameras that see four individually defined markers will instantly adjust to their approximate positions in **EVaRT** (as in Figure 8-6). If a camera does not see all four markers or sees more than four markers, it will be displayed at the origin, facing down as in Figure 8-6. This camera will not have a seed calibration, which is acceptable. Refer to

“Extending the Seed Calibration” on page 8-19. If the camera is not seeing all of the points, first try one or more of the following steps:

1. Adjust the threshold to see four centroids.
2. Insert Masks to eliminate stray data points.
3. Move the camera position so that it sees four defined markers. In Figure 8-6, a poorly positioned camera will be shown as a camera situated at the origin.
4. If one camera is seen in the exact opposite position in the room, the orientation (up/down) must be changed in the Lenses tab in the Calibration Settings menu. This usually occurs when cameras are tilted more than 90° or mounted upside-down.

Figure 8-6. Poorly Positioned Camera 4 Results in a Non-Seeded Camera (Camera #4)


EVa RealTime
File Layouts View Tools Help
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Calibrate
Refine
Seed Calibration
Details...
Calibrate
Wand Calibration
Collect
Floor Calibration
Calibrate Floor
0.000 (4)
Join Virtual
Run
Reset IDs
All On
1
2
3
4
5
6
7
8
MotionAnalysis
300
60
Z
mm

D:\Patient Data\10100a

☑ Preview Calibration

Filename: CalSeed

☐ OK to Overwrite

Duration: 100 (Seconds)

Length: 500

Filename: CalWand

☐ OK to Overwrite

Marker Center to Floor: 12.7

☑ Enable Tracking

☑ Enable Identifying

☑ Enable Skeleton

○ Connect To Cameras ● Raw Files:

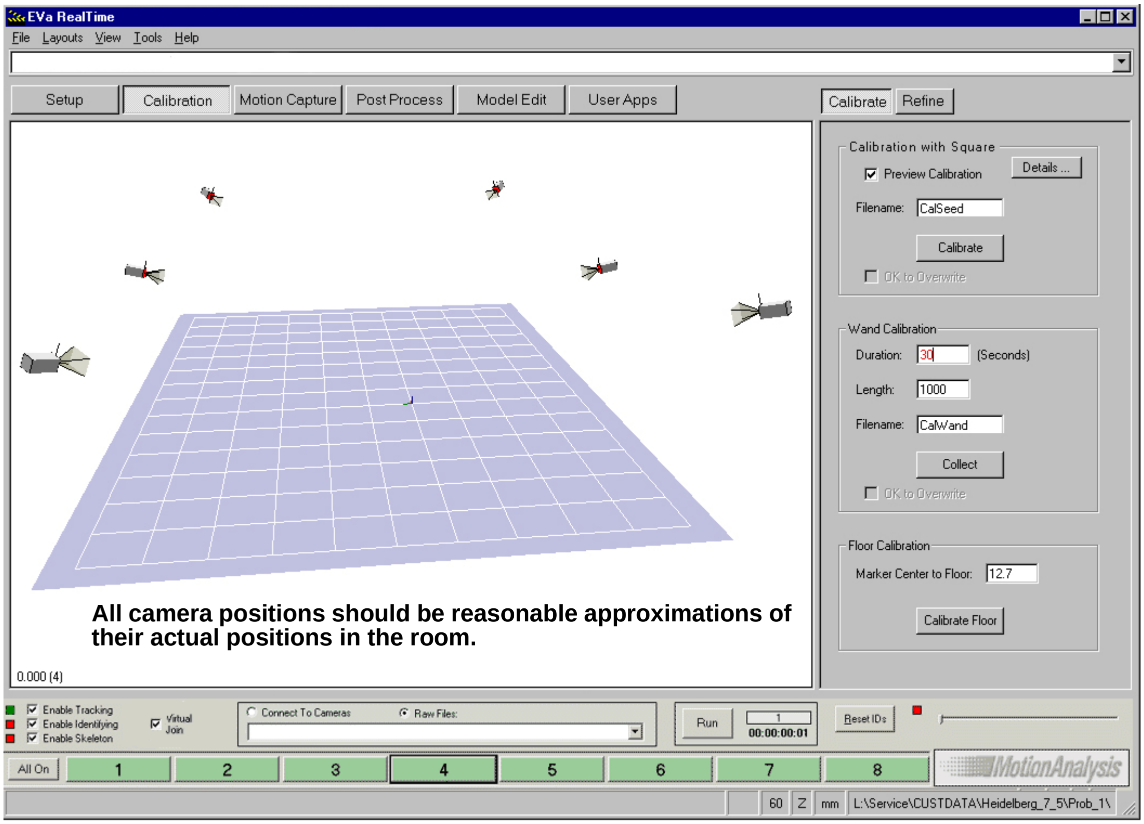
1

00:00:00:01

Example: The camera does not see the Calibration Square. Click on the camera to identify it.

Once you have all of your cameras positioned and oriented correctly, press the **Collect and Calibrate** button (see Figure 8-7). This creates the **CalSeed.vcX** (vc1, vc2… vcN) files and consists of one frame of data stored in your current data folder. Your camera buttons at the bottom should now be yellow in color, indicating that all cameras are seeded (see Figure 8-8). Fully calibrated cameras show up as Green, but this does not happen until after wand calibration is completed.

Figure 8-7. Properly Seeded Cameras


EVa RealTime
File
Layouts
View
Tools
Help
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Calibrate
Refine
Calibration with Square
Details ...
Calibrate
Wand Calibration
Collect
Floor Calibration
Calibrate Floor
Run
Reset IDs
All On
1
2
3
4
5
6
7
8
MotionAnalysis

All camera positions should be reasonable approximations of their actual positions in the room.

☑ Preview Calibration

Filename: CalSeed

☐ OK to Overwrite

Duration: 30 (Seconds)

Length: 1000

Filename: CalWand

☐ OK to Overwrite

Marker Center to Floor: 12.7

0.000 (4)

☑ Enable Tracking

☑ Enable Identifying

☑ Enable Skeleton

☑ Virtual Join

○ Connect To Cameras ● Raw Files:

1

00:00:00:01

60 Z mm L:\Service\CUSTDATA\Heidelberg_7_5\Prob_1\

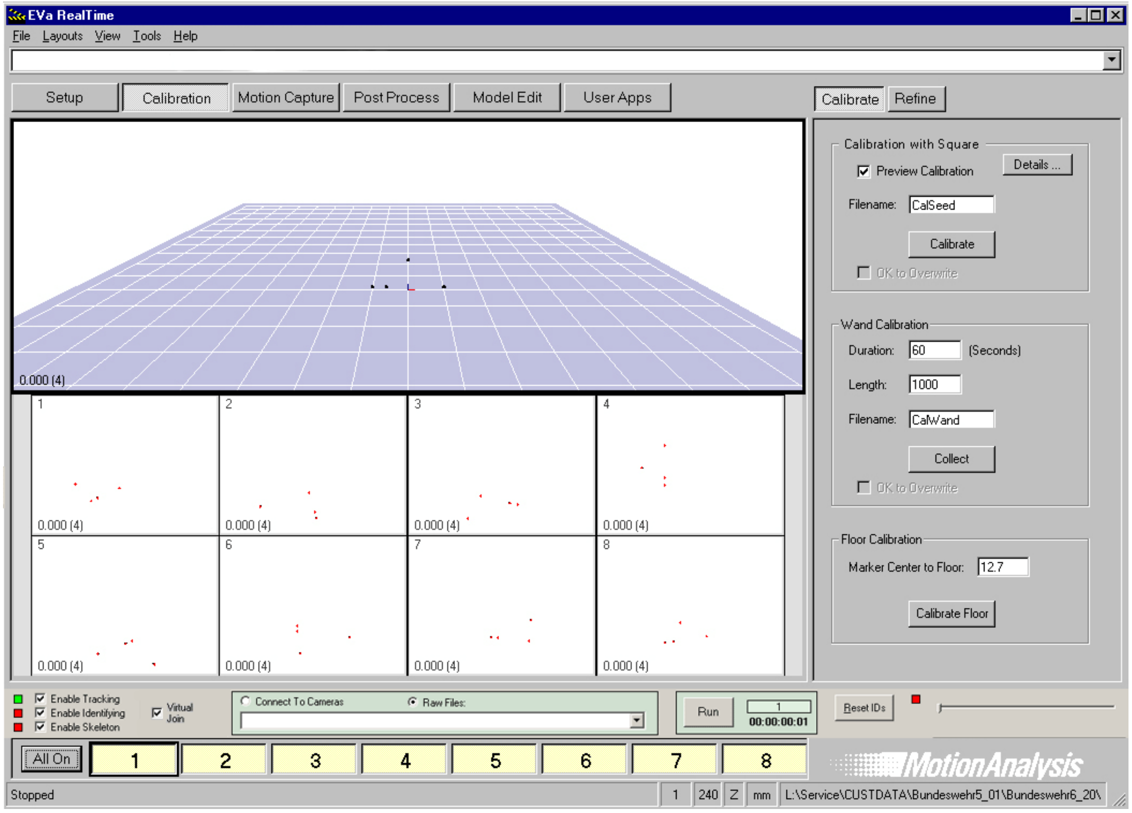
This completes the square part of the Square and Wand Calibration.

Wand Calibration of Cameras

1. In the Wand Calibration box on the right hand side, set the wand length to your wand size. Make sure that you are using only a three-point wand.
2. Set the duration of the trial. The duration should be sufficiently long enough to wave the wand through most of the volume that you want calibrated. Smaller volumes take less time to complete.
3. Click the **Collect and Calibrate** button and start waving the wand side to side and up and down through the volume. You want to spend about 1/3 of the data collection time with the wand parallel to each of the three X, Y, & Z axes.

Note: It is recommended that you view the wand movement through the volume at least for the first few times. To do this you must select **Layouts > Top/Bottom**. One window should reflect the 3D view and the area where it is possible to see the wand waving through the volume. The other is the 2D view where the individual camera coverage of the wand in the volume is seen. To show all cameras, press the **All On** button. In the 2D view, right-click and select **Smear Display**. This allows the wand to draw its paths across each camera view. A good wand calibration will fill most of the 2D Display.

Figure 8-8. Seeded Cameras; 3-D and 2-D View (all cameras on)


EVa RealTime
File Layouts View Tools Help
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Calibrate
Refine
0.000 (4)
1
2
3
4
5
6
7
8
Calibration with Square
Details ...
Calibrate
OK to Overwrite
Wand Calibration
Collect
OK to Overwrite
Floor Calibration
Calibrate Floor
Reset IDs
Run
00:00:00:01
All On
MotionAnalysis

☑ Preview Calibration

Filename: CalSeed

Duration: 60 (Seconds)

Length: 1000

Filename: CalWand

Marker Center to Floor: 12.7

☑ Enable Tracking

☑ Enable Identifying

☑ Enable Skeleton

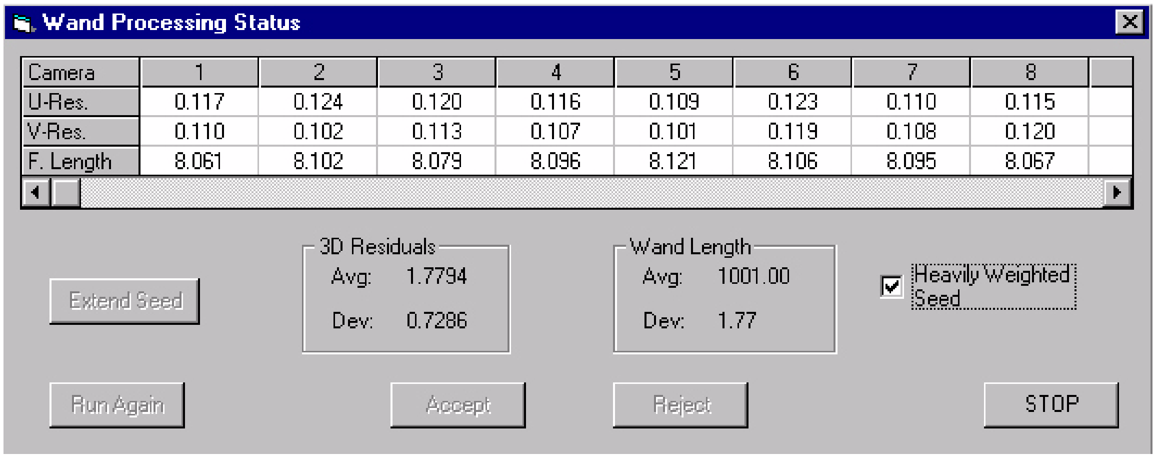
☑ Virtual Join

○ Connect To Cameras ● Raw Files:

Stopped | 1 | 240 | Z | mm | L:\Service\CUSTDATA\Bundeswehr5_01\Bundeswehr6_20\

4. Once the wand calibration duration has been completed, the program starts to determine the volume calibration, and a screen comes up with a series of numbers that decrease as the calibration nears the actual wand length and focal lengths of the camera lenses (see Figure 8-9).
5. At the bottom of the user interface, a progress bar ticks toward 100%. Once completed, the camera lenses should be very close to what was installed on the camera body (e.g. 6.023 mm for 6 mm lenses). If this is the case, and the wand length is very close (e.g. 500.06 mm for a 500.00 mm wand) to the original wand length, then the calibration is complete. Uncheck **Heavily Weighted Seed** and press **Run** again.
6. Press **Save Project**.

Figure 8-9. Wand Processing Status



Camera	1	2	3	4	5	6	7	8
U-Res.	0.117	0.124	0.120	0.116	0.109	0.123	0.110	0.115
V-Res.	0.110	0.102	0.113	0.107	0.101	0.119	0.108	0.120
F. Length	8.061	8.102	8.079	8.096	8.121	8.106	8.095	8.067

3D Residuals
Avg: 1.7794
Dev: 0.7286

Wand Length
Avg: 1001.00
Dev: 1.77

☑ Heavily Weighted Seed

Extend Seed Button

This button will seed the cameras that were not seeded during the Seed Calibration, based on the wand data. After extending the seed (clicking **Extend Seed**), all the camera buttons should be yellow. Click **Run Again** to complete the wand calibration for all cameras.

Run Again Button

This button continues the refinement of the wand calibration. If the numbers in Figure 8-9 continue to change, click **Run Again** for a more precise calibration.

Accept Button

Click this button if the calibration numbers look sufficient.

Reject Button

Click this button if the calibration numbers are unacceptable. Fix the problem, then select **Run Again.** A typical fix, without having to recollect the data, is that you can create a mask in one of the Raw Video **Cal-Wand.vcX** files.

Stop Button

If you need to stop in the middle of a calibration, or the numbers are not improving during a lengthy calibration click the **Stop** button.

Note: The Stop button is not a cancel button. You can click **Stop** and then **Accept** if you wish to keep the calibration numbers.

Floor Calibration

It is necessary to perform a floor calibration if your floor is uneven.

1. After the Seed and the Wand calibration is processed, place several markers on to the floor.
2. Press the **Connect** button and then the **Run** button. You should see the unidentified markers on the floor.
3. Enter the distance from the floor (your y=0 plane) to the center of the markers (maybe 20 mm) and press the **Collect and Calibrate** button in Floor Calibration.
4. It will tell you how much the calibration origin was moved and rotated with a six number display which stands for the XYZ and yaw, pitch and roll adjustments.

From VC Files

If you are doing this from VC files, you will need to do the following:

1. Select the **CalFloor.vc1** file from **File > Load Raw Files** (with the cameras disconnected).
2. Then press the **Run** button so that you see the unnamed markers on the floor in the 3D view.
3. Then press the **Collect and Calibrate** button in Floor Calibration.

CalFloor.vcX (optional)

You would not normally need this, but it is there to "level the floor" if needed. It is typical to take a single walk cycle and copy and paste it into 100 cycles. If the Calseed device is slightly tilted up or down, this can cause the stick figure to be walking above or below the floor at the ends of the cycles. To correct for this, you can spread 4 or more markers on the floor and press the Calibrate button in the Floor Calibration box.

Note: Make sure no other markers (ghost or otherwise) are visible in the 3D display, as it will tilt your new virtual floor to average them in as well.

Face Calibration

Refer to Appendix D, Capturing Facial Motion.

Calibration Files

The following are the types of calibration files generated in your selected capture folder:

Calseed.vcX

Calseed.vcX files (one for each camera) get written when you press the **Calibrate** button in the Calibrate with Square box and when you are connected to the cameras. If you are not connected to the cameras, you can use the Disconnect-Use Raw Files item and select the **Calseed.vc1** file to re-process the Calseed files. This is a kind of simulated realtime mode that allows you go back and process the **Calseed.vcX** files and evaluate your data files. When you press the **Calibrate** button in the Calibrate with Square box, it completely removes all of your calibration information and replaces it with the seed or approximate calibration for each camera.

Note: vcX means the set of files that end in vc1, vc2.... vcN if you have N cameras.

Calwand.vcX

Calwand.vcX files get written when you press the **Calibrate** button in the Calibrate with Wand box and when you are connected to the cameras. If you are not connected to the cameras, you can process the data in the simulated real time mode as above. The software uses the current system calibration (which is normally the results of the seed calibration, but can be otherwise) and refines the calibration. The calibration includes the exact location and orientation of each camera with respect to the origin, the lens distortion parameters for each camera, and other details about the cameras. At the successful completion of the wand calibration, the software asks if you want to save the system calibration. A **Yes** answer means that a file called **SystemCal.prj** gets written to the system directory.

Other uses for the **SystemCal.prj** file are when you launch **EVaRT**, the software automatically reads the **SystemCal.prj** file and when you exit the **EVaRT** program, it automatically writes the **SystemCal.prj** file into the system folder. The intent is so that you can launch the **EVaRT** software and it will remember its last good calibration without having to load any files. If you load a PRJ file or load a CAL file, it will overwrite the calibration information in memory with the contents of the PRJ or CAL file. Both contain calibration information, but the PRJ file also has the marker set information and template information.

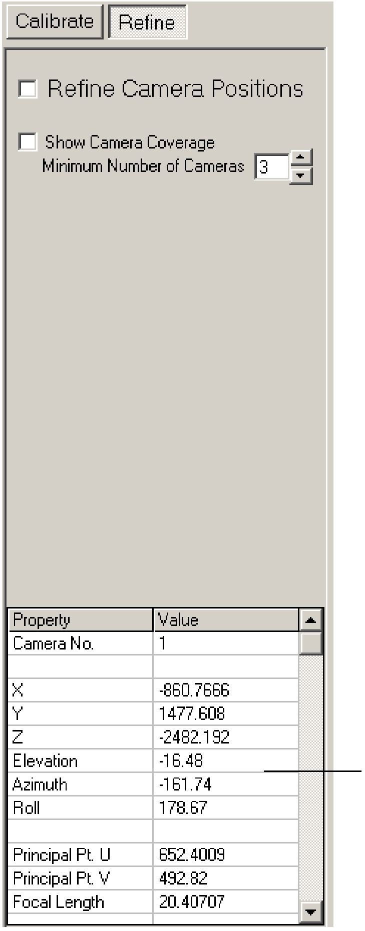
TrialN.cal

It is a good practice to use **TrialN.cal** for every capture you make. Every time you collect a trial in the **Motion Capture > Output** sub-panel, the system writes out the current calibration to a file that has the same name as your trial name, but with a **.cal** extension. This is normally not needed, but will allow you to load up the calibration at the time of the capture with the **File > Load Calibration...** menu item. If you changed the calibration for some reason and you know you were calibrated when the trial was collected, you can load up that as the current calibration in the software at a later time.

Refine Sub-Panel

After you calibrate the system, you can use the Refine sub-panel to either improve your calibration or to fix the calibration if a camera gets bumped or the cameras have moved slowly over time. When performed well, the Refine Cameras function can greatly improve the accuracy of the system, and will fix a bumped camera, all within 60 seconds. It is one of the most powerful tools in **EVaRT**. To use it, check the **Refine Camera Positions** check box press the **Run** button when connected to your cameras. Have a subject move about in the capture volume. Like with wand calibration, you must cover the entire capture volume and field of view for each camera with any marker data. If you get good coverage, then refined calibration will be very good. If you get only partial coverage, then you the results may be worse than not doing the refine.

Figure 8-10. Refine Sub-Panel



☐ Refine Camera Positions

☐ Show Camera Coverage

Minimum Number of Cameras 3

Property	Value
Camera No.	1
X	-860.7666
Y	1477.608
Z	-2482.192
Elevation	-16.48
Azimuth	-161.74
Roll	178.67
Principal Pt. U	652.4009
Principal Pt. V	492.82
Focal Length	20.40707

Camera Details in 2D View

The panel on the bottom of the Refine sub-panel displays the details of the selected camera in the 2D view. You can move and rotate the cameras in the 3D display by changing the X, Y, Z coordinates, and the Elevation, Azimuth, and Roll angles. This can be helpful to see if moving the cameras will help with seeing the volume better.

Refine Procedure

1. Connect to cameras (or select a Raw Video file).
2. Select and activate the **Refine Camera Positions** check box.
3. Press the **Run** button on the Real Time Dashboard.
4. Press **All On** on the Real Time Dashboard so that all camera views are displayed on the 2D Display.
5. Right-click on the 2D Display and select **Smear Display**. This will show you how much of each camera's field of view is being filled by the wand over time.
6. Start with the subject in one corner and as soon as the subject starts to move, check the check box for Refine Camera Positions.
7. Have the subject walk around the capture volume filling the entire volume. The subject is acting like a wand calibration. Have the subject walk with both arms slightly out so that all markers are easily identified. Then, have the subject walk the perimeter of the room, spiraling into the middle.
8. As soon as the subject has filled the room and reached the middle, press **Pause**.
9. A table of correction values will appear for all cameras included in the Refine sub-panel. The first three columns are the position changes of the cameras since the original calibration and the second three columns are the rotational changes. Changes of more than 1 mm are often significant and can result in a better calibration.
10. Click **OK** and save as a new project.
11. Press **Run** to start **EVaRT** again. You should now see lower residuals and fewer ghost markers.

There are a few things to be concerned about. Since this behaves just like a wand, and if the subject does not fill the volume during the Refine trial, the calibration can be poor and even worse than before the Refine. If the subject spends a lot of time in one area and not much in another, it can also be poor. If the markers are not identified, then there is no information for the Refine, so ensure that the subject is identified. Save the Refine as a new project (e.g. **Refine.prj**) so that if the new calibration is not as good as before, you can go back to the previous project file. The other thing to remember is that the Refine does not guarantee that the scale is exactly maintained. It just optimizes the camera locations to track the markers better. In effect, the scale of the room may change slightly. The reality is that Refining once does not change the scale. It is not recommend to do many Refine Cameras in a row to improve the results, since this may change the scale.

Note: You do not need an identified stick figure to refine, you only need to see 3D unnamed (or named) markers to refine the calibration.

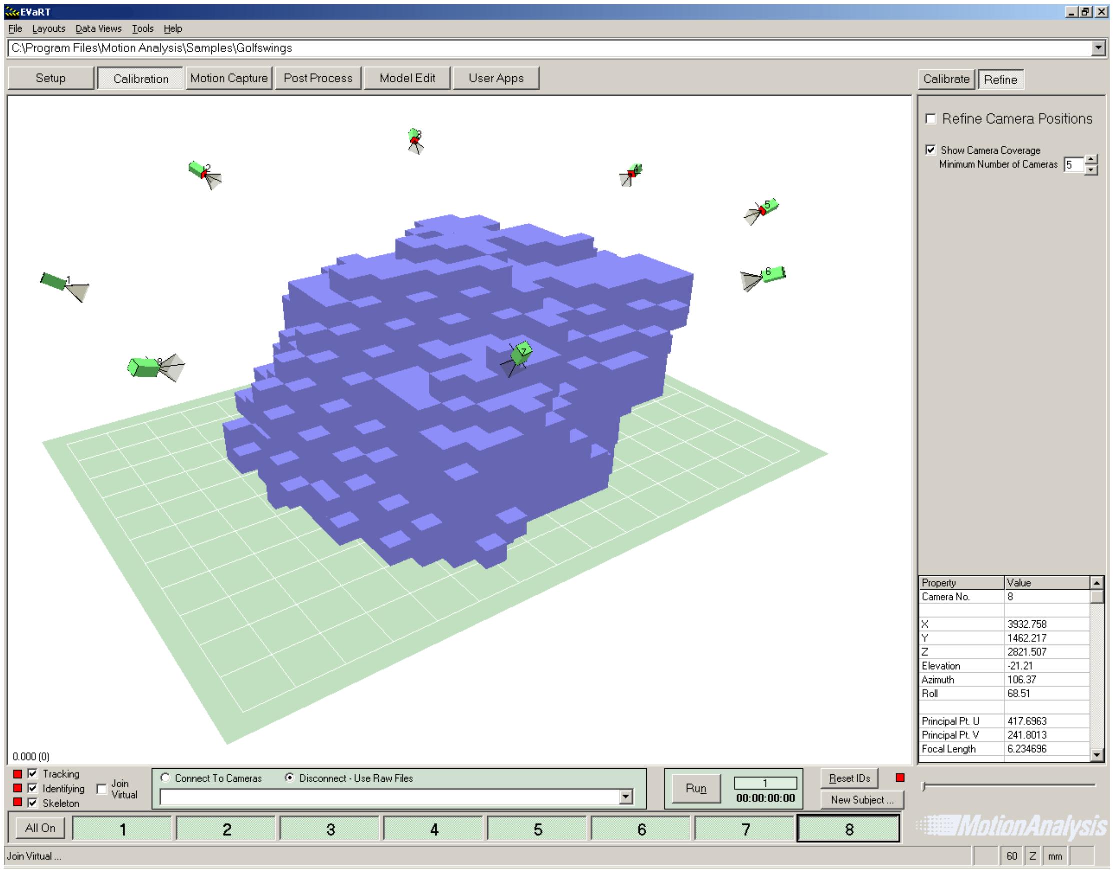
You can use any 3D data points to Refine the calibration. There does not need to be a template or a stick figure. Any data that fills the volume will be sufficient.

Show Camera Volume

Show Camera Volume is useful for telling you about how well your cameras are aimed and how much camera overlap you have. To see the camera volume:

1. Select the **Show Camera Coverage** check box in the **Calibration > Refine** sub-panel.
2. Right-click in the 3D view and select **Show Volume**.

Figure 8-11. Show Camera Coverage, Volume


EVaRT
File Layouts Data Views Tools Help
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Calibrate
Refine
1
2
3
4
5
6
7
8
All On
1
2
3
4
5
6
7
8
Run
Reset IDs
New Subject ...
MotionAnalysis

C:\Program Files\Motion Analysis\Samples\Golfswings

☐ Refine Camera Positions

☑ Show Camera Coverage

Minimum Number of Cameras 5

0.000 (0)

☑ Tracking

☑ Identifying

☑ Skeleton

☐ Join Virtual

○ Connect To Cameras ● Disconnect - Use Raw Files

1

00:00:00:00

Join Virtual ...

60 Z mm

Property	Value
Camera No.	8
X	3932.758
Y	1462.217
Z	2821.507
Elevation	-21.21
Azimuth	106.37
Roll	68.51
Principal Pt. U	417.6963
Principal Pt. V	241.8013
Focal Length	6.234696

Calibration from Previously Collected Files

This section describes how to simulate a calibration using previously recorded data. A simulated collection of **EVaRT** square or wand data is done the same way that you can simulate tracking Raw VC data. Just follow these steps:

1. Disconnect from your cameras.
2. Select **Raw Files** on the Real Time Dashboard.
3. Load the **CalSeed.vc1** file. At this point, you can mask out any extraneous data points if necessary.
4. Press the **Run** button on the Real Time Dashboard.
5. In the Calibrate sub-panel, press **Calibrate** in the Calibration with Square box.
6. The cameras buttons on the Real Time Dashboard should turn Yellow which indicates calibration is square, but not wand calibrated. White means not square. Green means fully calibrated.
7. Select **Raw Files** on the Real Time Dashboard.
8. Load the **CalWand.vc1** file. At this point, you can mask out any extra data points that might be causing problems. This feature allows you to utilize wand data sets if there are extra markers in the field of view of one or more cameras.
9. In the Calibrate sub-panel, press **Calibrate** in the Calibration with Wand box. You will see the wand results, see the cameras move to their final place, and see the measured focal distances.

Tips for Getting More Accurate Data

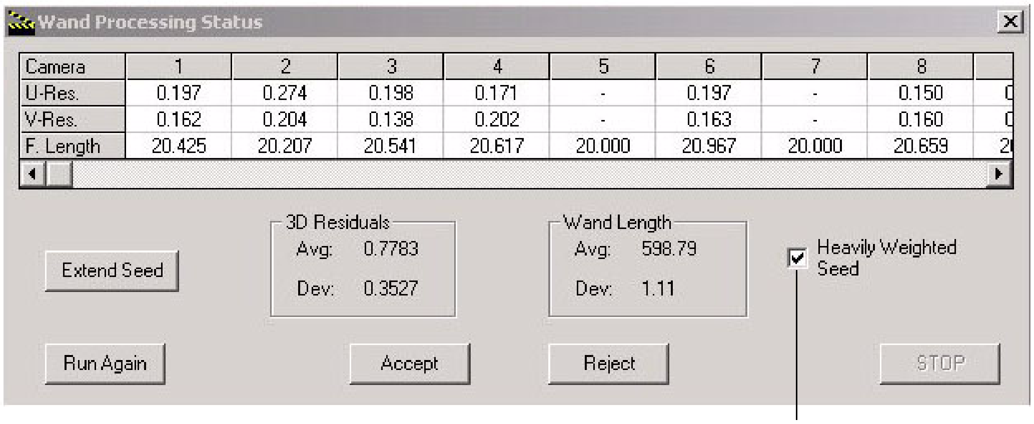
If the wand length is relatively close (e.g. 501.00 mm for a 500.00 mm wand), then select **Heavily Weighted Square** and **Run Again**. This keeps the Video origin very close to what the Calibration Square device defined as the origin. This is required by Biomechanics researchers where force plates are installed in the floor. If the number is much larger or much smaller, then proceed to Extending the Seed Calibration in the following section.

Extending the Seed Calibration

If one or more cameras are not seeing the four-point Calibration Square device for any reason, they have not been properly calibrated and it shows up as a white camera button. The camera is shown on the floor at the origin point down, as shown in Figure 8-6 on page 8-9. This will result when you have a large capture volume and only some cameras see the Calibration Square or a camera threshold may be set incorrectly. This is not a problem. You can use the wand data to get the camera calibration seeded, then process the wand data again so the camera (or cameras) get both square and wand processing. The steps for this are as follows:

1. Calibrate using the Calibration Square as described in “Calibration Frame Tab” on page 8-5. Cameras that are Yellow are seeded. Those that remain White are unseeded and show up on the floor, at the origin pointing down.
2. Process the wand data. The cameras that saw the Calibration Square will show as Green camera buttons; the unseeded cameras remain White.
3. Extend the calibration seed by clicking **Extend Seed Calibration.** This will then seed those cameras previously unseeded.
4. Click on **Run Again**. This runs the wand data again for all cameras. After this, all cameras should be Green (calibrated).

Figure 8-12. Wand Processing Status Window



Camera	1	2	3	4	5	6	7	8
U-Res.	0.197	0.274	0.198	0.171	-	0.197	-	0.150
V-Res.	0.162	0.204	0.138	0.202	-	0.163	-	0.160
F. Length	20.425	20.207	20.541	20.617	20.000	20.967	20.000	20.659

3D Residuals
Avg: 0.7783
Dev: 0.3527

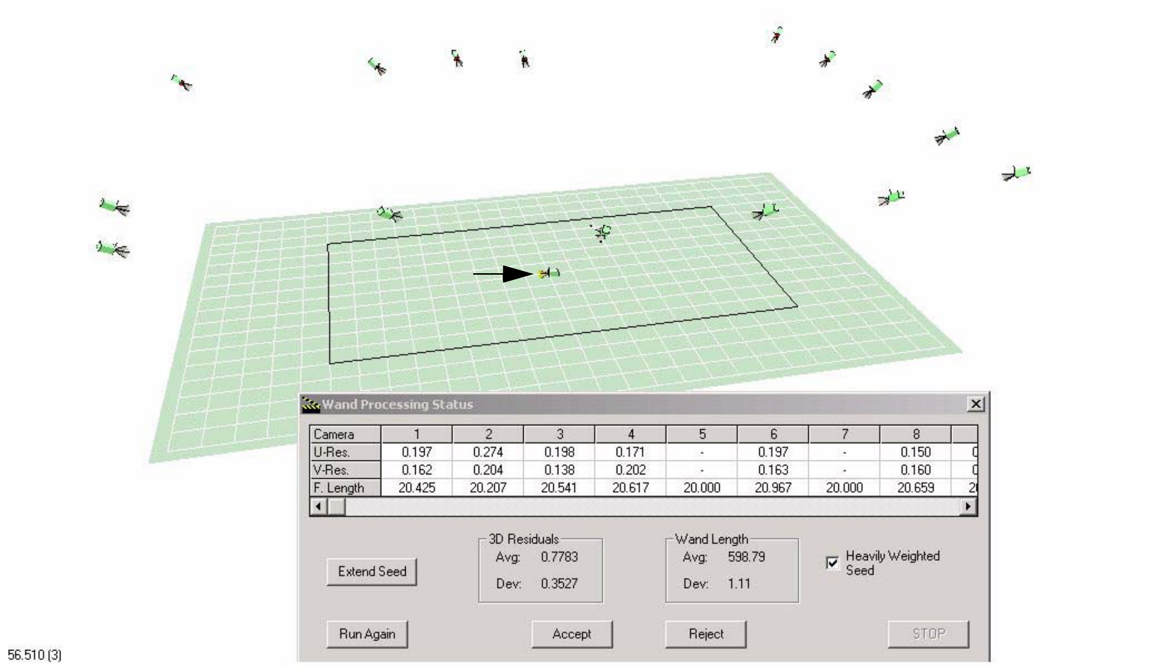
Wand Length
Avg: 598.79
Dev: 1.11

☑ Heavily Weighted Seed

Heavily Weighted Seed

Cameras 5 and 7 are not seeded. Their cameras buttons stay white.

Figure 8-13. Extend Seed—After First Pass


56.510 (3)
Wand Processing Status
Extend Seed
Run Again
Accept
Reject
STOP

Camera	1	2	3	4	5	6	7	8
U-Res.	0.197	0.274	0.198	0.171	-	0.197	-	0.150
V-Res.	0.162	0.204	0.138	0.202	-	0.163	-	0.160
F. Length	20.425	20.207	20.541	20.617	20.000	20.967	20.000	20.659

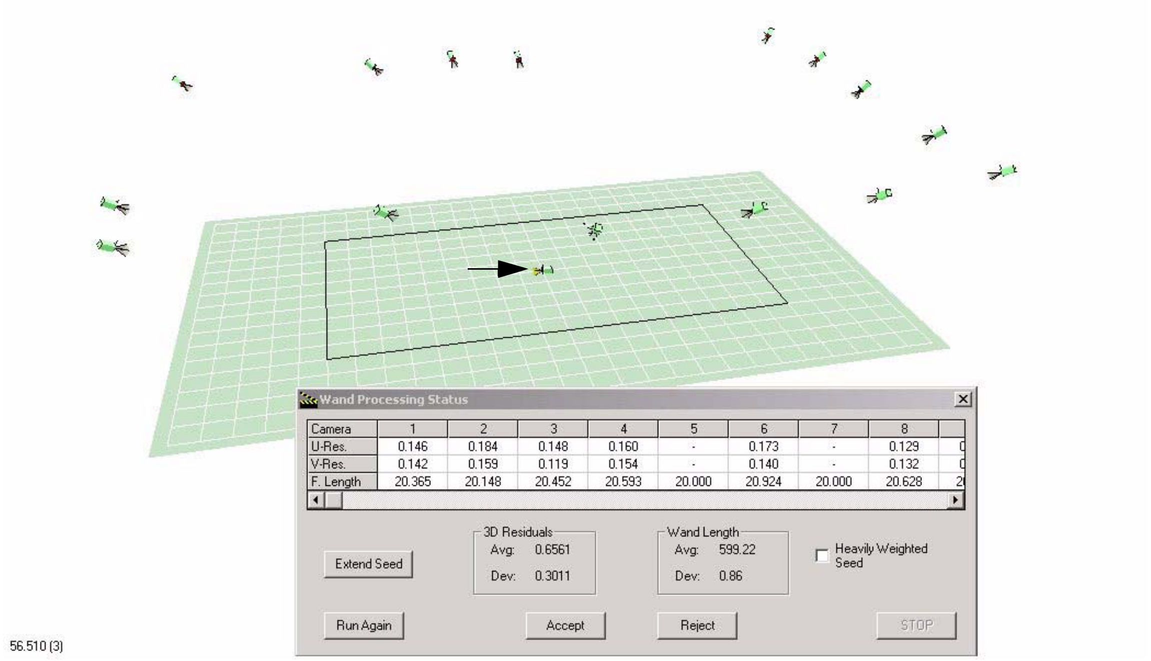
3D Residuals
Avg: 0.7783
Dev: 0.3527

Wand Length
Avg: 598.79
Dev: 1.11

☑ Heavily Weighted Seed

5. After the second pass, turn Heavily Weighted Seed **OFF**. Click **Run Again**.

Figure 8-14. Extend Seed—After Second Pass


56.510 (3)
Wand Processing Status
Extend Seed
Run Again
Accept
Reject
STOP

Camera	1	2	3	4	5	6	7	8
U-Res.	0.146	0.184	0.148	0.160	-	0.173	-	0.129
V-Res.	0.142	0.159	0.119	0.154	-	0.140	-	0.132
F. Length	20.365	20.148	20.452	20.593	20.000	20.924	20.000	20.628

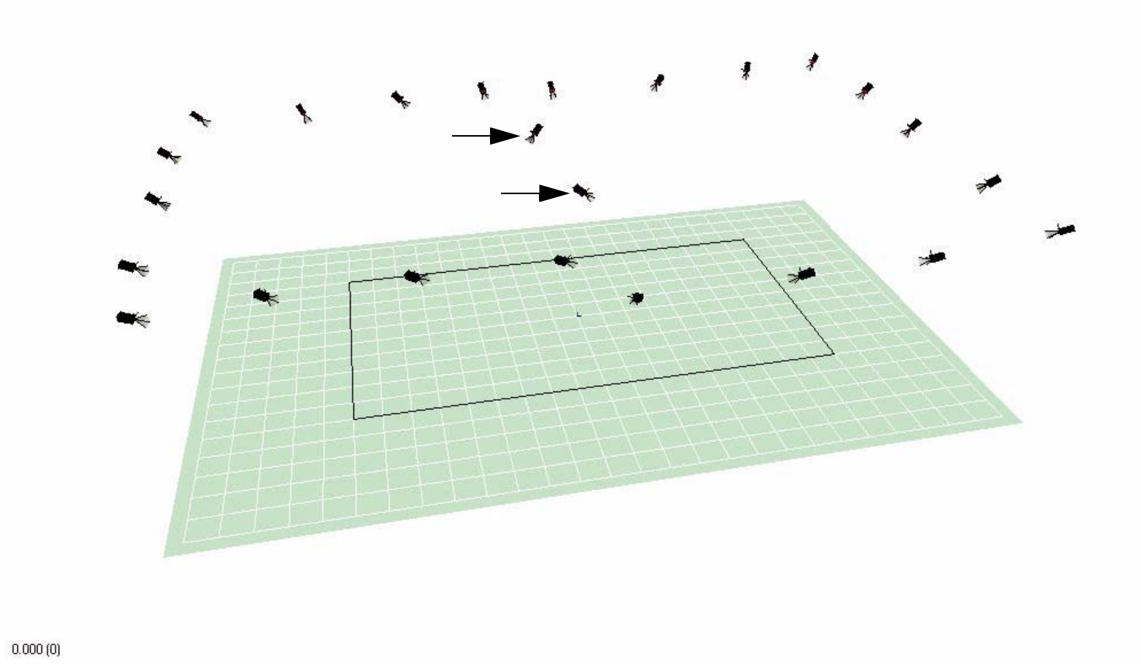
3D Residuals
Avg: 0.6561
Dev: 0.3011

Wand Length
Avg: 599.22
Dev: 0.86

☐ Heavily Weighted Seed

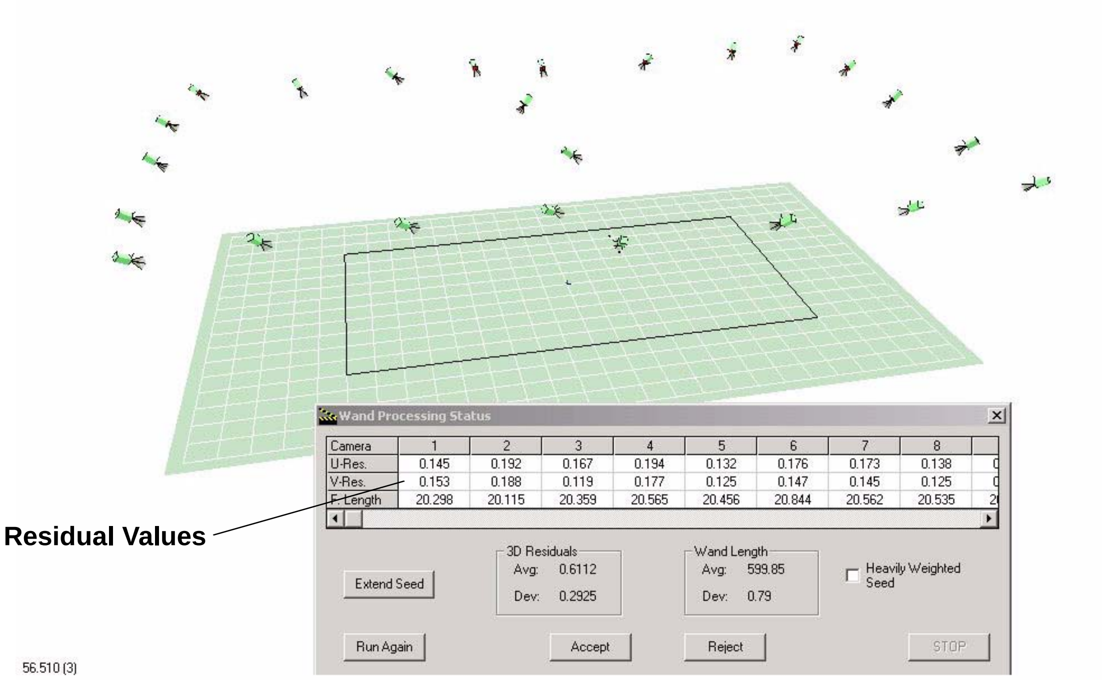
6. Press **Extend Seed**, with Heavily Weighted Seed **OFF**.

Figure 8-15. Extend Seed—After Extend Seed



7. Press **Run Again**.

Figure 8-16. Extend Seed—Third/Final Pass


Residual Values
56.510 (3)
Wand Processing Status
Extend Seed
Run Again
Accept
Reject
STOP

Camera	1	2	3	4	5	6	7	8
U-Res.	0.145	0.192	0.167	0.194	0.132	0.176	0.173	0.138
V-Res.	0.153	0.188	0.119	0.177	0.125	0.147	0.145	0.125
F. Length	20.298	20.115	20.359	20.565	20.456	20.844	20.562	20.535

3D Residuals
Avg: 0.6112
Dev: 0.2925

Wand Length
Avg: 599.85
Dev: 0.79

☐ Heavily Weighted Seed

Note: After you have clicked on **Extend Seed**, check that the residual value for each camera is at a reasonable level. If all cameras do not eventually seed, you will need to check your Wand coverage.

Post Processing Square and Wand Data

It is possible to process the square and wand data after the data has been collected. This is helpful if you did not have the time to process it during the capture or if you lost the project file that contains the calibration information. The steps are as follows:

Note: You must have the **CalSeed.vcX** and the **CalWand.vcX** files from the data capture session.

1. Select **Raw Files** in the Real Time Dashboard and then select **CalSeed.vc1**. Select your CalSeed data set in the data capture folder.

Note: You can create a mask to eliminate unwanted markers or reflections. Reselect the **CalSeed.vc1** file again and press the **Calibrate** button in the Calibration with Square section.

2. In the Calibration with Square section of the Calibration sub-panel, click **Calibrate**.
3. Select **Raw Files** in the Real Time Dashboard and then select **CalWand.vc1**. Select your CalWand data set in the data capture folder.

Note: You can create a mask to eliminate unwanted markers or reflections. Reselect the **CalSeed.vc1** file again and press the **Calibrate** button in the Calibration with Square section.

4. In the Calibration with Wand section of the Calibration sub-panel, click **Calibrate.**
5. Complete the wand calibration as described in “Wand Calibration of Cameras” on page 8-11.

At this point you now have your cameras calibrated and you may proceed with your data collection.

Chapter 9 Motion Capture Panel

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Multiple Tracking Objects	9-7
Objects Sub-Panel	9-8
Output Sub-Panel	9-11
Recording Data	9-14
Tracking Strategies and Tips	9-15

Overview

Motion Capture is the mode where you will spend most of your time during a recording session. In this mode you can:

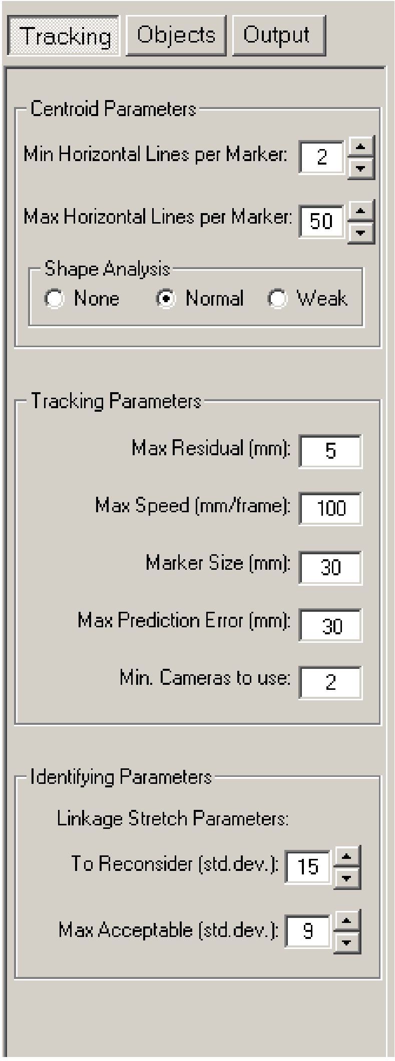
- Create and improve a template
- Set the tracking parameters
- Save data in a variety of file formats

These functions are described in this chapter.

There are a few preliminary steps that must be taken before starting a successful motion capture session. Tracking parameters tuned to your system must be set. Names must be assigned to the markers that will be used. These names constitute a marker set and building this set is actually done using the Model Edit tools discussed in Chapter 11, Model Edit Panel. A template specific to the markers in use must be created. A template describes the minimum and maximum distances that separate linked markers, such as the distance between the right elbow and the right wrist. Templates are created using Motion Capture tools and Post Process tools described in Chapter 10, Post Processing Panel. Once these steps are completed, you are ready to begin a motion capture session.

Tracking Sub-Panel

Figure 9-1. Tracking Parameters



Centroid Parameters

Min Horizontal Lines per Marker: 2

Max Horizontal Lines per Marker: 50

Shape Analysis: ○ None ● Normal ○ Weak

Tracking Parameters

Max Residual (mm): 5

Max Speed (mm/frame): 100

Marker Size (mm): 30

Max Prediction Error (mm): 30

Min. Cameras to use: 2

Identifying Parameters

Linkage Stretch Parameters:

To Reconsider (std.dev.): 15

Max Acceptable (std.dev.): 9

The Tracking sub-panel allows you to edit the key parameters that are used when acquiring and tracking data. Figure 9-1 is an example of the parameters entered for a typical setup. These settings are all saved in the **project** (**.prj**) file. These parameters fall into three categories:

Centroid Parameters

Centroid Parameters control the minimum and maximum number of video lines that are permitted for marker images. If an image size falls outside these limits, no centroid will be calculated for it and it can never become a marker image.

Min. Horizontal Lines per Marker

Sets the minimum number of scan lines a marker must occupy on the camera's sensor for it to qualify as a marker. The value of the parameter entered is dependent on the size of the markers and the distance the camera is away from the markers. A typical value for a 1 inch marker would be **2**. For Eagle-4 cameras, these values will generally double to 4 lines per marker.

Max Horizontal Lines Per Marker

Sets the maximum number of scan lines a marker must occupy on the camera’s sensor for it to qualify as a marker. Again, the value of the parameter entered is dependent on the size of the markers and the distance the camera is away from the markers. A typical value for a 1 inch marker would be **50**.

Shape Analysis

Filters out the centroids of blobs that are not round (e.g. a marker is partially obscured, or two markers have merged).

Tracking Parameters

Tracking parameters are used when correlating the images from several cameras to establish marker coordinates in three dimensions.

Max Residual

Is the maximum average error when rays from several cameras are combined to establish the coordinates of one marker. If the residual exceeds this amount, it is assumed that these rays are not close enough together to be seeing the same marker. This parameter value should not be less than 4 times, and no greater than 8 times, the average residual value. The average residual value is found in the lower-left corner of the screen when the cameras are running. A typical parameter value is **5 mm**.

Max Target Speed (millimeters/frame)

Sets a speed limit on the markers. A marker’s track is eliminated when it surpasses this value. When tracking the tip of a golf club or other object with fast moving markers, it is possible that this value will need to be increased. A typical parameter value is **100 mm/frame**.

Marker Size (millimeters)

Limits the size of the markers so that higher residual cameras do not see more than one centroid for the same marker. This parameter should be set to the physical size of the markers in use (25.4 millimeters = 1 inch). This parameter will also set the size of the markers that appear on the 3D Display.

Max Prediction Error (millimeters)

Is is used to identify a marker in the next frame. While the software is tracking a marker, it is assumed that it will not deviate by more than this amount along its path. Otherwise the marker will not be identified in the frame. A typical parameter value is **30 mm**.

Min. Cameras To Use

Tells the software what the minimum number of camera’s rays are required to triangulate (track) a marker during a frame. Some users will benefit by setting this value to **3** if spurious data points (ghost markers) are seen in the motion capture sequence.

Identifying Parameters

Linkage Stretch Parameters, in Identifying Parameters, control the acceptable lengths of links in a template. Typically, body templates have rigid linkages, so the numbers should be low. Facial captures are considerably more elastic in nature to account for soft tissue deformation, so the numbers should be higher. These are used in the Rectify function, not Template Rectify.

To Reconsider (std. deviation)

Is the maximum amount of linkage stretch allowed for a linkage to be established. A typical parameter value is **15**.

Max Acceptable (std. deviation)

Is the maximum acceptable amount of linkage stretch in standard deviations before the linkage is broken. This parameter value should be no less than **3**.

Correctly Identifying Markers Automatically: Motion Capture Mode

In the Motion Capture interface, markers are correctly identified if:

1. The current "dynamic template" is good and the data fits into it.
2. All markers are present.
3. The **Identifying** check-box has been activated.

The software keeps a separate dynamic template, which is used during Real Time or simulated Real Time tracking and only applies in the Motion Capture interface. It starts with the user created Template (from the Create Template button) in the current project and dynamically adjusts itself as the markers are seen to stretch outside of the limits set in the current Template. This is useful when you are using the **EVaRT** system for live performances. If markers are all identified, right or wrong, the dynamic template is updated for that frame. Pressing the **Reset IDs** button in the Real Time Dashboard resets the Dynamic Template back to its original, user created Template. This is to be done if the identification gets mixed up for any reason. It is a likely result of the template being stretched too much, perhaps after a mis-identification of markers. This causes the dynamic template to perform poorly and it needs to be reset back to the original user created template.

For the Reset IDs function to be successful, all of the markers used when creating the template must be present. When the markers are un-identified, the software keeps looking in the current dynamic template to identify the markers. The software will also continue to identify the markers whose history it knows about, so you can see frames where some markers are correctly identified and other markers are shown as the black unnamed marker crosses. When about 1/3 or more of the markers become un-identified, the software tries to apply the dynamic template over the entire marker set to re-identify the markers.

Dynamic Template Stretch Limits

These are parameters that affect how much stretch the dynamic template is allowed to change, which are set with in the **Motion Capture >Tracking > Identifying Parameters: Linkage Stretch Parameters: To Reconsider (std. dev.) and Max. Acceptable (std.dev).** This does not apply to the Post Processing Template Rectify feature, but only to the Motion Capture mode of tracking.

To Reconsider

To Reconsider is a unit-less measure of linkage stretch checks which the current frame marker identifies against the current dynamic template. The dynamic template is a measure of the minimum and maximum of each of the linkages, which is updated as the person moves about (and the linkage lengths change in time). If any of the linkages are stretched beyond their limits, the identities of markers at both ends of those linkages are changed to "Unnamed". The limiting factor is taken as multiples of the standard deviation of the linkage length. A typical number for a tight setting is 7 and for a loose setting is 12. A bigger number will allow the template to grow more quickly, but can cause mis-identifications. A smaller number may keep the software from identifying the markers correctly.

Max Acceptable This is a unit-less measure of linkage stretch that is applied to all unnamed markers in the current frame in an attempt to find proper identities for them. It is applied after any linkages were deemed to have stretched excessively. This number is usually 2 or 3 less than the To Reconsider value.

Building a Template from the Range of Motion Trial

A template tells the software what the minimum and maximum distances are that can exist between markers of a relatively fixed relation. It is necessary to allow the software to identify each marker in each frame. Template information is saved in the project (**.prj**) file.

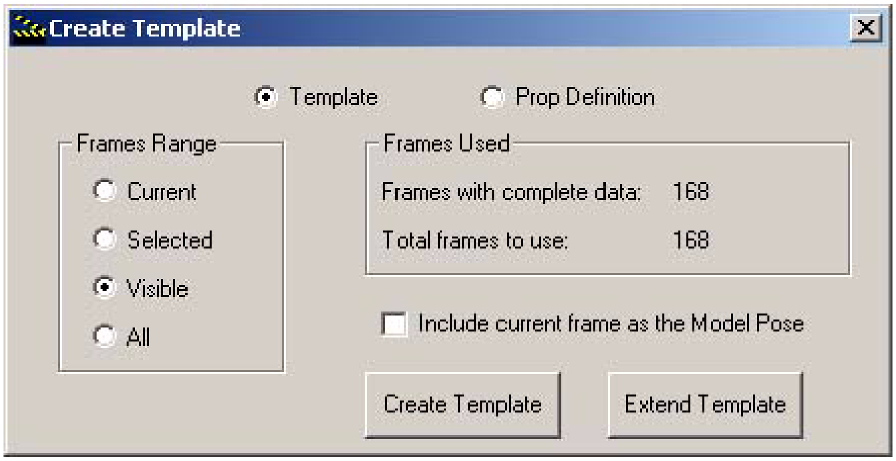
Before a template can be created, a marker set that will apply to the subject being captured must exist. If such a marker set does not exist, it must be built using the Model Edit tools described Chapter 11, Model Edit Panel. Once an appropriate marker set exists, follow these steps to create a template.

1. Choose **Motion Capture** from the Mode Buttons.
2. Choose **Output** from the panel buttons.
3. Check the **Tracked ASCII (TRC) or Tracked Binary (TRB)** check box on the Output sub-panel.
4. Type a file name in the name box and press **Enter**.
5. Set the Duration (seconds) between **10** and **20**.
6. Start collecting the range of motion data of the subject by having the person stand in the middle of the capture volume with arms extended, palms parallel to the floor with thumbs facing forward, and all markers in full view.
7. Click **Record** on the Output sub-panel.
8. The subject must stay in an initial frozen position for two or three seconds.
9. After standing frozen in this initial position for up to five seconds, the person must move through a complete range of motion by moving and twisting, ensuring that each linkage exhibits the full extent of stretch that will be experienced during subsequent motion capture sessions. Exaggerated motion must be avoided and all markers should remain in full view. This step should not require more than fifteen seconds.
10. After ten seconds passes from the moment **Record** was clicked, the system will automatically stop collecting and tracking marker data.

At this point, a Tracked ASCII (TRC) or Tracked Binary (TRB) file has been generated in the current directory and is ready for editing. Next, the markers must be hand identified according to the marker list built for the subject’s marker set (assuming that the marker list was already defined prior to the motion capture).

11. Choose **Post Process** from the Mode Buttons.
12. Click **Quick ID** and identify the unnamed markers according to the conventions described in Appendix C, Marker Sets.
13. Click **Rectify**. This applies the naming convention across all the frames of data.
14. Manually cleanup and identify all tracks in this range of the motion file. The template should be defined as at least 75% of the visible frames selected.
15. Select **Template**.
16. Click **Create Template**.
17. Select the appropriate Frames Range:
    - **Current**—the current displayed frame
    - **Selected**—frames highlighted in blue, low to high in dashboard
    - **Visible**—what is displayed across the screen, as a function of the time zoom
    - **All Frames**—all frames
18. Click **Create Template**.

Figure 9-2. Create Template Dialog



Create Template

● Template ○ Prop Definition

Frames Range

○ Current
○ Selected
● Visible
○ All

Frames Used

Frames with complete data: 168
Total frames to use: 168

☐ Include current frame as the Model Pose

Prop Definition

Selecting Prop Definition creates a **<projectname>.prop** file that is a rigid body measurement of the object. This .prop file can then be selected as one of the "Additional Tracking Objects" in the **Motion Capture > Objects** panel.

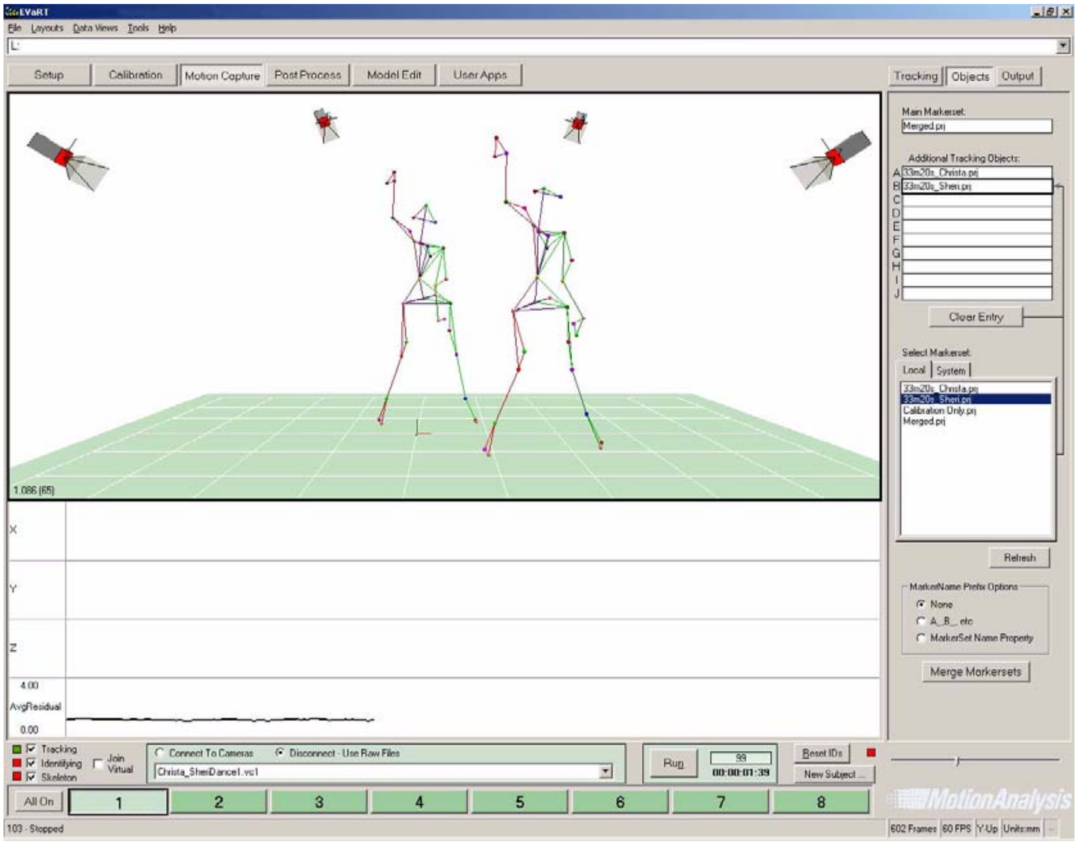
Multiple Tracking Objects

The problem with tracking many people and props (all Tracking Objects) is that you need a unique project file and template for every combination of things you want to track. The project file has to have exactly the right number and names for the combination of markers that you want to use. You then create a template for these combinations and load that project when that combination of objects is to be tracked.

With the Multiple Tracking Objects (MTO) architecture, you need to have one project and template for each object. You record the range of motion for each object separately and create a template for each object and save it in each object's **.prj** file.

For example, when Subject1 and Subject2 and the Subject3 are to be brought into the volume to track, you select the Tracking Objects **Subject1.prj**, **Subject2.prj**, and **Subject3.prj** files. The base project file, entered into the **Main Marker Set:** text box, that you load can be a "Calibration Only" project file (recommended for a higher number of objects that are entering and exiting the data set) or a project file with one marker set. You can then place projects with multiple, pre-defined subjects in the **Additional Tracking Objects:** text boxes. These text boxes can hold up to 5 additional objects. For more information, see the Objects Sub-Panel section on the following page.

Figure 9-3. Multiple Tracking Objects—Multiple Dancers


EVaRT
File
Layouts
Data Views
Tools
Help
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Tracking
Objects
Output
1.086 (65)
X
Y
Z
4.00
AvgResidual
0.00
Clear Entry
Local
System
Refresh
Merge Markersets
Run
Reset IDs
New Subject ...
All On
1
2
3
4
5
6
7
8
MotionAnalysis

Main Markerset: Merged.prj

Additional Tracking Objects:
A 33m20s_Christa.prj
B 33m20s_Sheri.prj
C
D
E
F
G
H
I
J

Select Markerset:
33m20s_Christa.prj
33m20s_Sheri.prj
Calibration Only.prj
Merged.prj

MarkerName Prefix Options
● None
○ A_B_ etc
○ MarkerSet Name Property

☑ Tracking
☑ Identifying
☑ Skeleton
☐ Join Virtual

○ Connect To Cameras ● Disconnect - Use Raw Files
Christa_SheriDance1.vc1

99
00:00:01:39

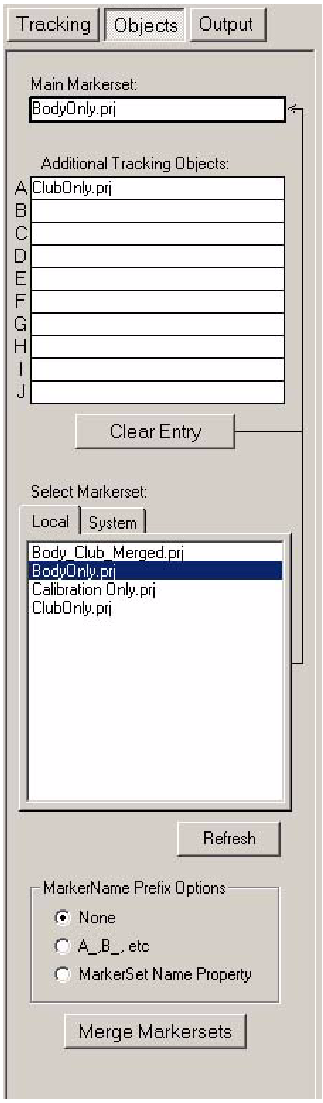
103 - Stopped
602 Frames
60 FPS
Y-Up
Units:mm

Objects Sub-Panel

The Objects sub-panel sets the main marker set and allows you to work with multiple tracking objects (MTOs) while tracking, and bring them into your motion capture data set. A good example of this would be bringing in a second dancer in a dance routine, or a prop such as a golf club when analyzing a golfer’s swing.

Under any condition, it is easier for the software to identify a marker set that has greater asymmetry. You may change the order of the additional tracking objects, as listed in the Objects sub-panel to vary the results of your data set. It has been found that the more asymmetrical of your multiple tracking objects should be put at the top of the Additional Tracking Objects list.

Figure 9-4. Objects Sub-Panel



Main Markerset: BodyOnly.prj

Additional Tracking Objects:
A ClubOnly.prj

Select Markerset: Local
Body_Club_Merged.prj
BodyOnly.prj
Calibration Only.prj
ClubOnly.prj

MarkerName Prefix Options
● None
○ A_,B_, etc
○ MarkerSet Name Property

Main Marker Set

Allows you to choose which object data set is your primary data set in the tracking session.

Additional Tracking Objects

Allows you to add multiple tracking objects (i.e. people, props, etc.) to your tracking session.

Select Marker Set

Lists and allows you to manage which marker sets are used in the project tracking session.

Merge Marker Sets

Merges the marker sets of the MTOs to become one merged project.

System Objects

System Objects is a feature used to help track objects that are known to be rigid objects. The advantage in using this feature over using a standard objects with a Template is that rigid objects can be more robustly tracked and can have several markers define the 6 DOF Rigid Object coordinate system. This is useful for tracking and identifying props such as swords, baseball bats, and other sport accessories. To use this feature:

1. Create a project file with just the marker names of the prop. Each prop should have its own marker set and associated project file. There must be three or more markers for rigid bodies to work; five or more markers is recommended. Marker names do not matter when they become tracked as Rigid Objects. Linkages are not needed as Rigid Objects have implicit linkages between all markers on the object. You can create linkages to help you visualize the prop when it is tracked if you wish but when a rigid object is identified as such, both the markers and the linkages are shown as a purple color.
2. Create a Prop file. Record some number of frames of the prop (maybe 2-5 seconds), and then load the Tracks into Post Processing. Identify the markers and click the **Create Template** button. Select **Rigid Object** as the template type. The Create Template changes words to “Create Prop File". A message pops up telling you that you created a prop file in your current project folder. A second message informs you that "The type will become rigid when selected on the Objects sub-panel and that a Rigid Object Template has been created.
3. Using the prop file in you local folder, the prop file can be selected as any Tracking Object in the **Motion Capture > Objects** sub-panel. Props can be selected as normal tracking objects and they take up one of the tracking object slots. Currently the coordinate system of the prop is displayed in the Motion Capture 3D Display. When you record a trb or trc file, the XYZ coordinates of the prop are also recorded. Visually, you can see the coordinate system of the Rigid Object defined. The coordinate system displayed has the origin at the center of mass of the defining markers and the directions of the XYZ axes are defined parallel to each of the calibration coordinate system axes as defined on frame 1 of the capture.
4. Create a global System Objects folder. If you want to build a library of props, you can create a folder under the launch folder of **EVaRT** (next to the Sounds folder) and name it SystemObjects (note: no space between System and Objects). Copy any props you want to use into the SystemObjects folder. You will need to quit and relaunch **EVaRT** and then you will see a new section at the bottom of the

Motion Capture > Objects sub-panel with the heading “System Objects.” You can select prop files from that list to go into any of the "Additional Tracking Objects" slots.

5. Order the objects in the Tracking Objects sub-panel. The priority for identifying objects is A-B-C-D-E and the Main Marker set is identified last. You will want to put the props at the beginning of the list into the top slots. Done this way, it is less likely for the props to be embedded into one of the other human objects.

Advanced Example Data Set

This example data set, found in **C:\Program Files\Motion Analysis\EVaRT50\Samples\24_Eagle 5 People** shows a five person capture of 1200 frames of data. Each person has their own project file which defines the marker set template for that person.

The TRB file creation process was done as follows:

1. The **FiveStars1.trb** was generated from the VC files. All markers are unnamed. This was done while using the **All_Five.prj** project file.
2. For each person:
   a. Load their project file (for example, load the **GreavesTemplate.prj** file).
   b. Read in the Unnamed marker file (in this case it is the file **FivesStars.trb**).
   c. Saved out to a new TRB file (in this case **FiveStarsGreaves.trb**).
   d. Tracked the data by finding frames where the template identified the markers and used rectify to identify all the markers over all frames. Filled in data where necessary. In the Greaves example go to frame 1, select Template ID, select all frames, and then select Rectify. This will ID all the markers over all the frames.
   e. When fully tracked, deleted all unnamed markers and saved the result to a TRC file.
   f. Used Virtual Marker Join to reconstruct missing markers and saved this back out to the TRC file.
   g. Used the final TRC file to create skeleton for import into Maya.

From the above procedure you can see how the TRB files were used to track visible markers as much as possible. Then all marker reconstruction was done using TRC files.

You can see the difference by loading, for example, the **JohnTemplate.prj** and then loading the **FiveStars1_John.trb** and comparing that to what you see when you load **FiveStars1_John.trc**.

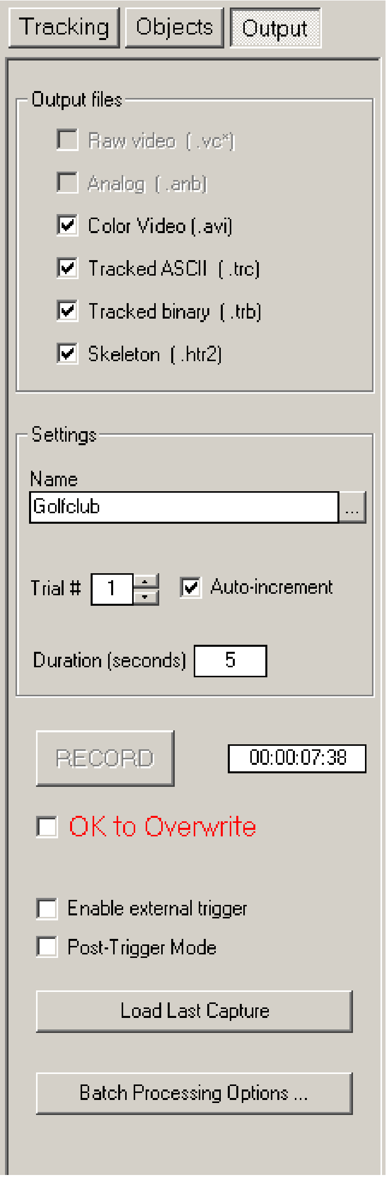
Note: It is important to keep the project files in a particular order for each time the MTO function is performed for a given data set.

Output Sub-Panel

The Output sub-panel is used when the motion capture recording is initiated. It is set by the following procedure:

1. Choose the output file type (at least 1).
2. Enter a file name.
3. Set the file length (in time).
4. If necessary, set the external trigger mechanism.

Figure 9-5. Output Sub-Panel


Tracking
Objects
Output
RECORD
Load Last Capture
Batch Processing Options ...

Output files

☐ Raw video (.vc*)
☐ Analog (.anb)
☑ Color Video (.avi)
☑ Tracked ASCII (.trc)
☑ Tracked binary (.trb)
☑ Skeleton (.htr2)

Settings

Name: Golfclub

Trial # 1 ☑ Auto-increment

Duration (seconds) 5

00:00:07:38

☐ OK to Overwrite

☐ Enable external trigger
☐ Post-Trigger Mode

Output Files

The Output files are the files generated during a motion capture session. This section of the Output sub-panel allows you to choose which files are to be produced and saved in the project file directory.

Settings

Settings allows you to provide the specifics for your generated output files. This includes the name of your files, the trial number, and the duration of the trial. The duration lets you set the length of the motion capture, so there is little wasted time in the session.

Note: VC, TRB, TRC, ANB, AVI, and TC files are all associated in the project by file name. If you rename the output files, they may not be recognized and they will lose their association to the project.

OK to Overwrite

This allows you to redo an existing file, once it has been saved.

Enable External Trigger

When using an external trigger mechanism, you will need to check this box for the software to recognize it. You can install an external trigger by plugging it directly into your COM1 port on your Host computer.

Post Trigger Mode

When the Post Trigger Mode check box is activated, it enables the software to record the data from the end of the session, backwards based on the capture duration (X) that has been set (i.e. from the end of the data capture to –X seconds). This is useful for captures where there is no defined starting point or event, but the ending is well organized and smooth, and you would like to capture only the final moments.

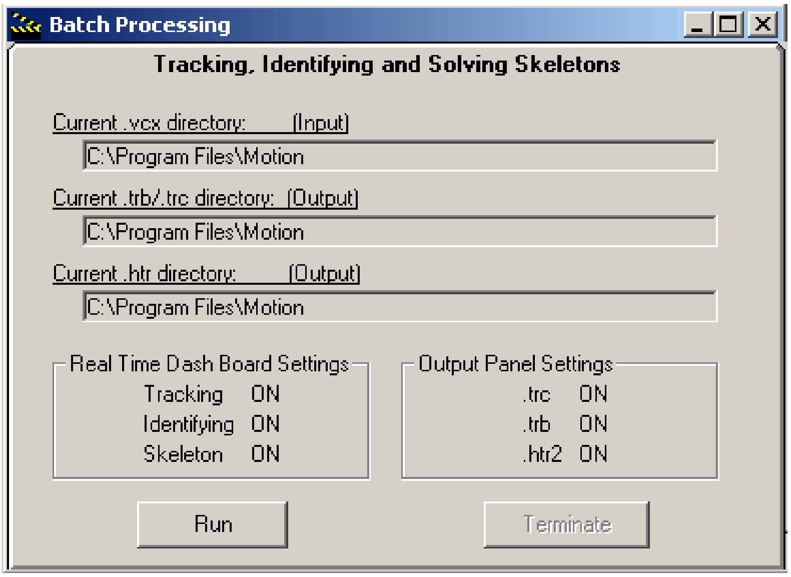
Batch Processing

Batch Processing gives an overview of the current Tracking, Identifying, and Solving configuration in **EVaRT**.

Pressing the **Run** button will track and/or identify and or solve all of the VC (raw video) data in a particular directory. This input and output directories are set using the **Setup > Misc** sub-panel.

This type of batch job has been designed to never overwrite any TRB, TRC, HTR, and HTR2 files. If a batch job is terminated, partial files are detected and pressing run again will pick up where the previously terminated batch job left off.

Figure 9-6. Batch Process Interface



Tracking, Identifying and Solving Skeletons

Current .vcx directory: (Input)
C:\Program Files\Motion

Current .trb/.trc directory: (Output)
C:\Program Files\Motion

Current .htr directory: (Output)
C:\Program Files\Motion

Real Time Dash Board Settings
Tracking ON
Identifying ON
Skeleton ON

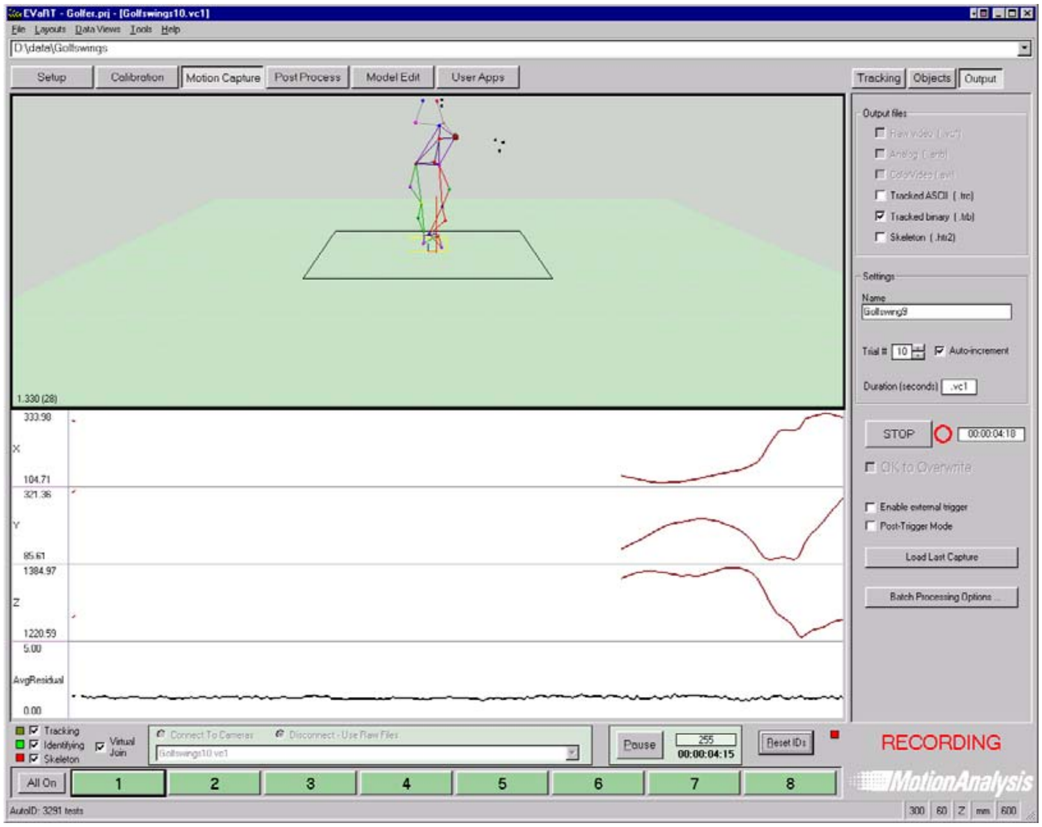
Output Panel Settings
.trc ON
.trb ON
.htr2 ON

Recording Data

After setting up the template, always be sure to save the project file (**File > Save Project**). Use the following procedure to record a motion capture session.

1. Select the Output sub-panel.
2. Select the output file types to be generated.
3. Enter a name for the file.
4. Enter a trial number. This is optional and will self increment if multiple trials of the same name are recorded.
5. Enter the estimated time length for the motion capture recording.
6. Select **External Trigger Mechanism** if you are using an external trigger.
7. Select **Post Trigger Mode** if you only want the last portion of your motion capture session. This function allows you to select from the end of the session, working backwards to a specified time point.
8. Click **Record**. You should see the word RECORDING in large red letters on the lower right corner of the interface. See Figure 9-7.

Figure 9-7. Recording Data



EVaRT - Golfer.prj - [Golfswings10.vc1]

D:\data\Golfswings

Output files

☐ Raw video (.vc*)
☐ Analog (.anb)
☐ ColorVideo (.avi)
☐ Tracked ASCII (.trc)
☑ Tracked binary (.tvb)
☐ Skeleton (.htr2)

Settings

Name: Golfswing9
Trial #: 10 ☑ Auto-increment
Duration (seconds): .vc1

00:00:04:18

☐ OK to Overwrite
☐ Enable external trigger
☐ Post-Trigger Mode

☑ Tracking
☑ Identifying
☑ Skeleton
☑ Virtual Join

○ Connect To Cameras ● Disconnect - Use Raw Files

Golfswings10.vc1

255
00:00:04:15

AutoID: 3291 tests

File
Layouts
Data Views
Tools
Help
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Tracking
Objects
Output
1.330 (28)
333.98
X
104.71
321.36
Y
85.61
1384.97
Z
1220.59
5.00
AvgResidual
0.00
STOP
Load Last Capture
Batch Processing Options ...
Pause
Reset IDs
RECORDING
All On
1
2
3
4
5
6
7
8
MotionAnalysis
300
60
Z
mm
600

9. When recording is complete, click **Load Last Capture** to replay the tracked data that was last recorded. This will automatically send you to the Post Processing mode.

Tracking Strategies and Tips

Speeding Up Tracking in EVaRT

Changing the Max Speed to 30 mm/frame and the Max Prediction Error to 10 mm greatly enhances tracking for most normal speed data sets. While this needs to be adjusted up for high-speed trials, keeping a 3:1 ratio works well. This can cut your CPU load by 50% or more.

Here is what is under the hood, see the **Motion Capture >Tracking** sub-panel.

Max. Speed

If a marker has NO track history (i.e. a new marker just found on this frame), how big of a sphere do we draw around its current location to look for its continuation in the next frame. This should affect only startup tracks. It can affect performance if it is TOO BIG by making the software check more points than are necessary. If it is TOO SMALL, it will not create contiguous tracks; the tracks will have many holes and lots of unnamed markers.

Max. Predictor Error

Max. Predictor Error determines a sphere around the projected (extrapolated) path trajectory into the next frame. If the marker is not found in that projected sphere, it is assumed to have disappeared. This should affect only continuing tracks with a history, which is the bulk of what is being tracked. This can have a big effect on performance if it is TOO BIG. If it is TOO SMALL, tracks will be broken up into smaller path fragments and there will be an excessive amount of unnamed markers.

Bring up the Task Manager and monitor the CPU usage. You can see this with trials you have already collected by selecting the Raw Video Files you collected, click the **Run** button. Change the above Tracking Parameters, press the **Run** button again and see the difference. Check that the **Setup > Misc** sub-panel is showing the **From Raw Video Files** and the Real Time speed option is selected.

Chapter 10 Post Processing Panel

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Viewing Your Data	10-2
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Unnamed Markers	10-10
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Editing Tracked Data

The **EVaRT** Post Process mode allows you to play back and edit tracked data stored in TRB (binary) and TRC (ASCII) files. Markers can be identified if they have gone unnamed during the recording session. Gaps and aberrations in data can be filled or fixed by hand, frame by frame, or by employing mathematical functions across entire sections of a data set. Up to ten operations can be undone if you make a mistake, but it is recommended that you save your work frequently.

Typically, an editing session requires having both the 3D Display and the XYZ Graphs open at the same time in two different Graphics Panes.

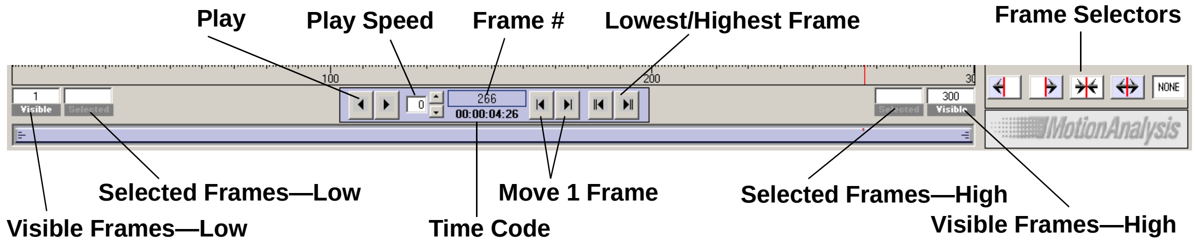
1. Click **Post Process** from the Mode Buttons.
2. From the Menu Bar, choose **Layouts > 2 Panes: Top/Bottom**.
3. Left-click in the Top Pane to select it.
4. Activate the 3D Display by pressing **F3** on the keyboard of by choosing **Data Views > 3D Display** from the Menu Bar.
5. Left-click on the bottom pane to select it.
6. Activate the XYZ Graphs by pressing **F4** on the keyboard of by choosing **Data Views > XYZ Graphs** from the Menu Bar. It will display X, Y, and Z tracked position data, and optionally, residuals, and the cameras that triangulated the markers.

Viewing Your Data

The XYZ Graphs will display none, any, or all markers you have selected in the Post Process panel. Selection of markers from a marker list is done with standard selection methods including **Shift** + click, **Ctrl** + click, and **Shift** + **Ctrl** + click. In addition, the top row of the marker list acts as a special selecting button. Markers can also be selected by simply clicking and **Ctrl** + clicking on markers in the 3D Display. Click on the back button to reset the previous list of selected markers.

The Post Process tools heavily utilize the Post Process Dashboard controls. These controls are itemized and described as follows.

Figure 10-1. Post Process Dashboard


Play
Play Speed
Frame #
Lowest/Highest Frame
Frame Selectors
100
200
1
Visible
Selected
0
266
00:00:04:26
300
NONE
MotionAnalysis
Selected Frames—Low
Visible Frames—Low
Move 1 Frame
Time Code
Selected Frames—High
Visible Frames—High

Current Frame

Current Frame is the frame that is currently seen in the 3D Display and is marked with a full height red line on the XYZ Graphs. The Current Frame number is found in the very center of the Post Process Dashboard.

Play Forward Button

The Play Forward button (default hot key is the **>** key.) plays forward through the data until the end and then repeat from the beginning. This also acts as a Stop button.

Play Backward Button

The Play Backward Button (default hot key is the **<** key) plays backward through the data until the beginning and then repeat from the end. This also acts as a Stop button.

Next Frame Button

The Next Frame Button (default hot key is the **F** key) moves the Current Frame forward by one frame. This also acts as a Stop button.

Previous Frame Button

The Previous Frame Button (default hot key is the **S** key) moves the Current Frame backward by one frame. This also acts as a Stop button.

Low Frame Button

The Low Frame Button sets Current Frame to the Low Visible Frame.

High Frame Button

The High Frame Button sets Current Frame to the High Visible Frame.

Time Zoom Slider

The Time Zoom Slider sets/indicates the Low and High Visible Frames. Double-clicking on this control expands the Visible frames to encompass all of the frames in the data set. If you only want to work with a specific range of frames, right-click on this slider to lock/unlock visible frames.

Low and High Visible Frames

The Low and High Visible Frames define the lower and upper limits of the visible frame range. The Current Frame is never outside of these limits. Absolutely no identifying or editing can occur on frames outside of the visible range, with the exception of the join tools. Their values are found in the white Visible Boxes and can be changed by typing numbers into these boxes and pressing **Enter** on the keyboard.

Low and High Selected Frames

The Low and High Selected Frames are the lower and upper limits of the selected frame range. These values can be changed by typing numbers into these boxes and pressing **Enter** on the keyboard. See “Selecting Frames” on page 10-4 for details.

Zoom In-Zoom Out

The XYZ Graphs right mouse pop-up menu includes these zooming features (default hot keys are the **I** and **O** keys). These features zoom in time (frames) centering on the Current Frame. Zooming occurs more quickly by using the hot keys.

The best way to zoom into a particular set of frames is to select the frames in the XYZ Graphs by dragging with the middle mouse and then pressing the Zoom In Hot Key. Even finer control over zooming can be accomplished by pressing **Shift** + middle-clicking to independently set the Low and High Selected Frames and then pressing the Zoom In hot key (**I**).

The XYZ Graphs also allows you to translate the data vertically and horizontally. This is accomplished by holding the **Alt** key while clicking and dragging the cursor inside the X, Y, or Z display.

It is often helpful to zoom into the data’s amplitude. Holding the **Alt** key and simultaneously pressing the left and middle mouse buttons zooms the data’s amplitude. The marker that was closest to the pixel on the display where zooming began becomes the Target Marker. Its data is centered either to the data in the Current Frame or optionally to the data in the frame that the cursor was on when zooming began. Data for this marker will remain centered on the screen at all times unless you forcibly translate it off the screen using **Alt** + click and drag.

Unzoom is a means of resetting the display such that zoom and translate values are equal to zero. The default Hot Key is **U** on the keyboard and it is an XYZ Graphs right mouse pop-up menu item.

Target Marker

Picking a marker out of a crowd of data is done by double-clicking directly on a marker’s data line. This action will deselect all other markers leaving only the display of the Target Marker.

Scaling

Other important view options that are general in nature are described here. These options can only be accessed as XYZ Graphs right mouse pop-up menu items.

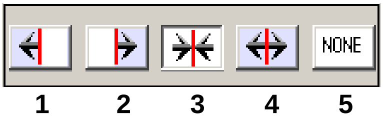
- **Auto Scale** dynamically scales the display to accommodate data in the visible frame range.
- **Uniform Scale** the display such that X, Y, and Z conform to a uniform range.
- **Show Residuals and Cameras** shows residuals and cameras along with XYZ data.

Selecting Frames

To the right of the Post Process Dashboard controls are five Frame Selector buttons. Refer to Figure 10-2.

1. **Select Backward** selects from the Current Frame to the Low Visible Frame.
2. **Select Forward** selects from the Current Frame to the High Visible Frame.
3. **Select Current Frame** selects only the Current Frame.
4. **Select Visible Frames** selects from the Low Visible Frame to the High Visible Frame.
5. **Select None Safe Mode**—nothing is selected.

Figure 10-2. Selecting Frames Buttons



Clicking any one of these buttons sets the Frame Selector mode that you can return to at any time by pressing **Esc** on the keyboard. The Frame Selector mode is a User Preference. The default mode is Select Visible Frames. This will also highlight the selected area in blue.

Joining Gaps in Data

Join functions are not always confined to selected frames as a conveniencer. For example, if you select only one frame in a gap of marker data, tools intended to fill that gap will seek out appropriate endpoints to that gap, store all necessary data in an undo buffer, and effect a repair to that gap without requiring you to tediously hand select the appropriate endpoints.

The smooth function smooths data within the selected frames with a Butterworth Filter algorithm. This is a low pass (high block), two-pass, 4th order, zero phase shift filter. This data can be spikes—created by frames in which a marker has experienced an acceleration greater than or equal to a selected value, or gaps—missing data.

Manually selecting frames is done by dragging the mouse in the XYZ Graphs with the middle mouse button pressed. Low and High Selected Frames can be independently picked by pressing the **Shift** key and middle clicking on the XYZ Graphs.

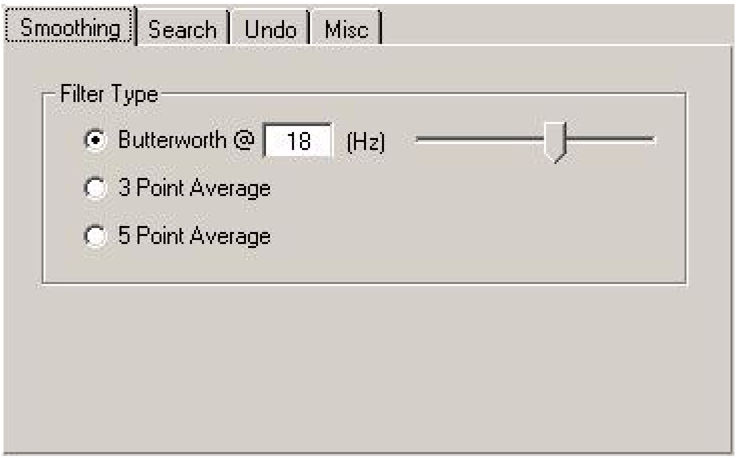
Select All Frames (default Hot Key is the **A** key.) displays and selects all frames in the data set. This is also a right mouse menu item on the XYZ Graphs.

Filters

The Eagle and Hawk digital cameras generate extremely clean, noise free data. For the majority of data captures, it is never necessary to modify the data by filtering or smoothing. Occasionally, however, it is useful to remove artifacts in the motion capture data. This can happen in the case of captures which contain a high number of marker occlusions or a large amount of marker merging (as it frequently happens with face tracking, for example).

For these purposes **EVaRT** provides 3 different smoothing filters that can be applied to tracking data. Each filter affects only the currently selected markers over the currently selected sample range. All three dimensions (X, Y and Z) of each marker are smoothed. To access the options dialog, select the **Post Process > Options...** button.

Figure 10-3. The Post Processing Options Dialog Showing the Smoothing Options Tab



● Butterworth @ 18 (Hz)
○ 3 Point Average
○ 5 Point Average

Butterworth Filter

The Butterworth filter is a low band-pass filter with excellent mathematical characteristics for biomechanical motion. The purpose is to remove high frequency motions (motions that are too fast for a person to actually perform) while leaving intact the frequencies of motion normal to human movement. The user has the choice of selecting how aggressively the filter will smooth the motion by choosing a frequency value. Lower values will cause a very smooth result while higher values will remain truer to the original data.

Figure 10-4. An Example of Original, Unfiltered Data with Some Unwanted Error

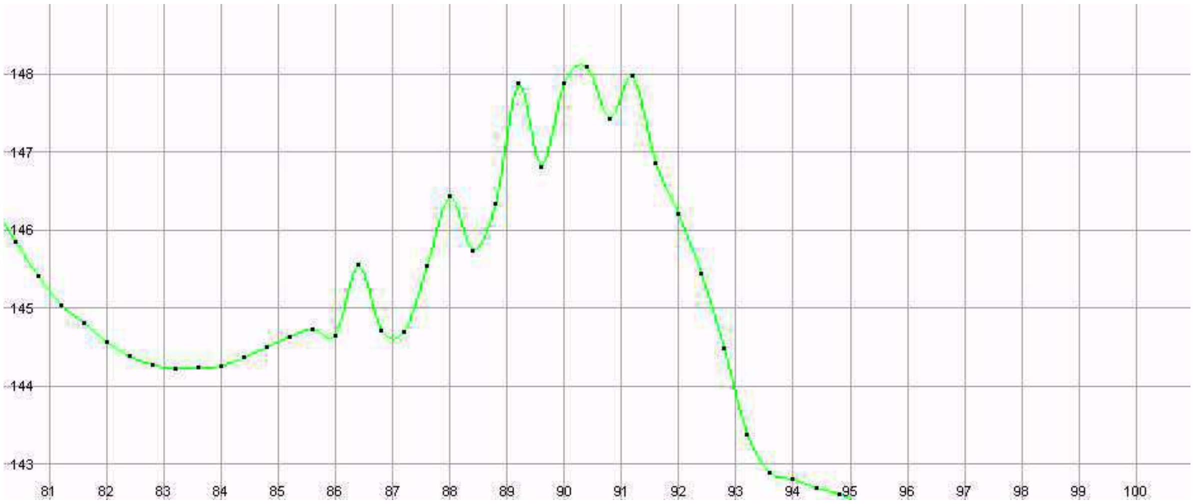


Figure 10-5. The Curve After an Application of the Butterworth Filter, with an Input Freq. of 3

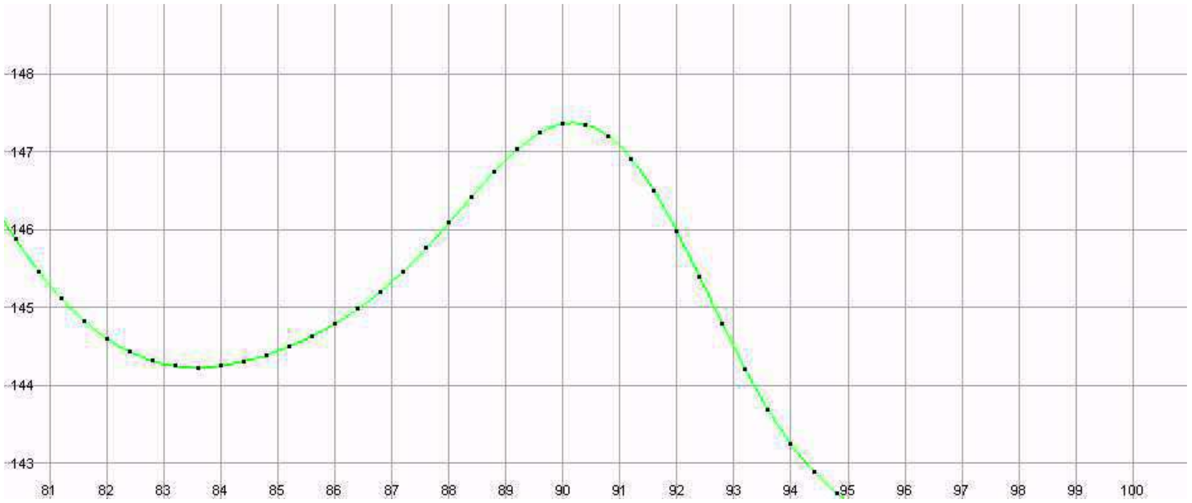


Figure 10-6. The Curve After an Application of the Butterworth Filter, with an Input Freq. of 6

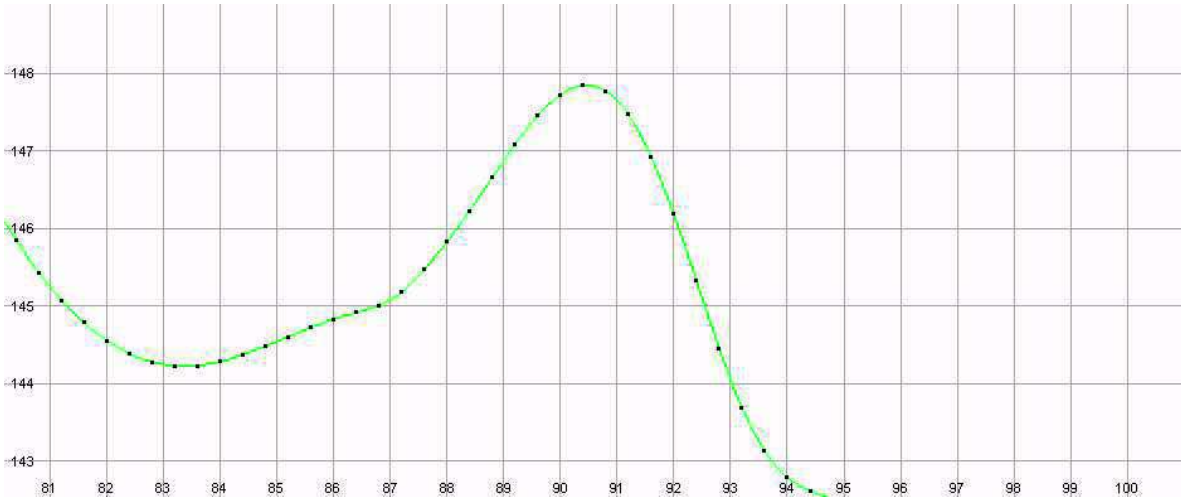


Figure 10-7. The Curve After an Application of the Butterworth Filter, with an Input Freq. of 12

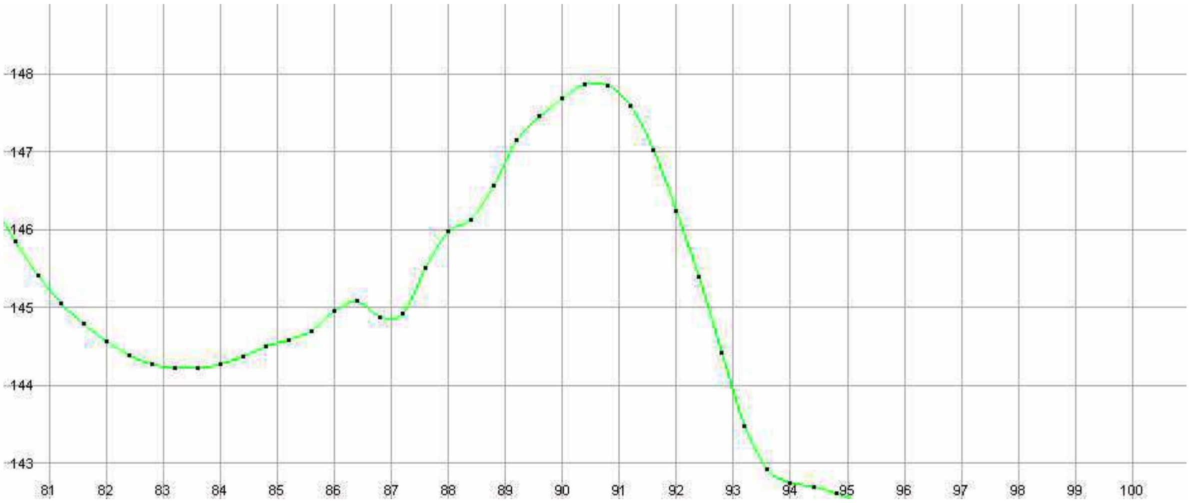
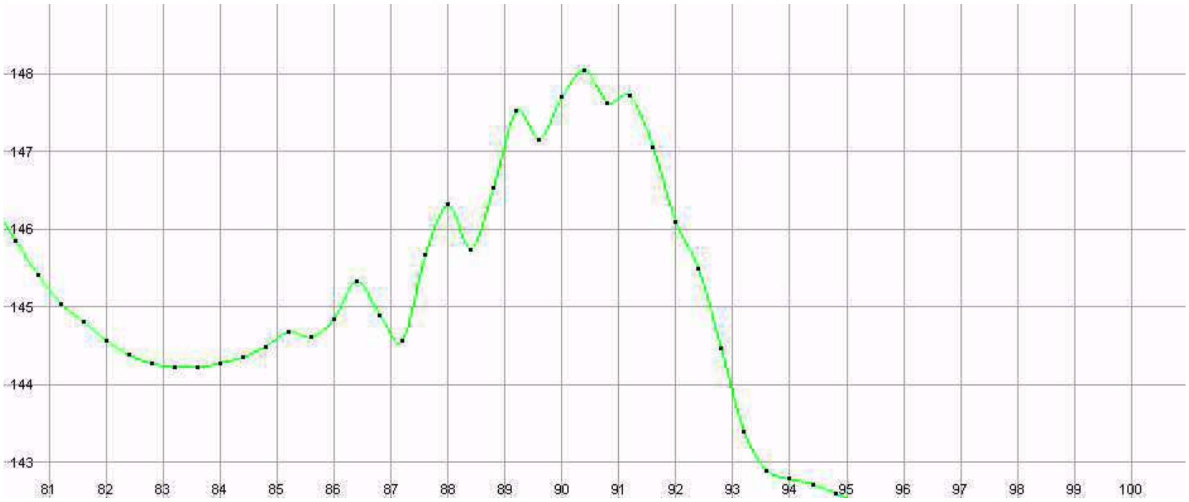


Figure 10-8. The Curve After an Application of the Butterworth Filter, with an Input Freq. of 18

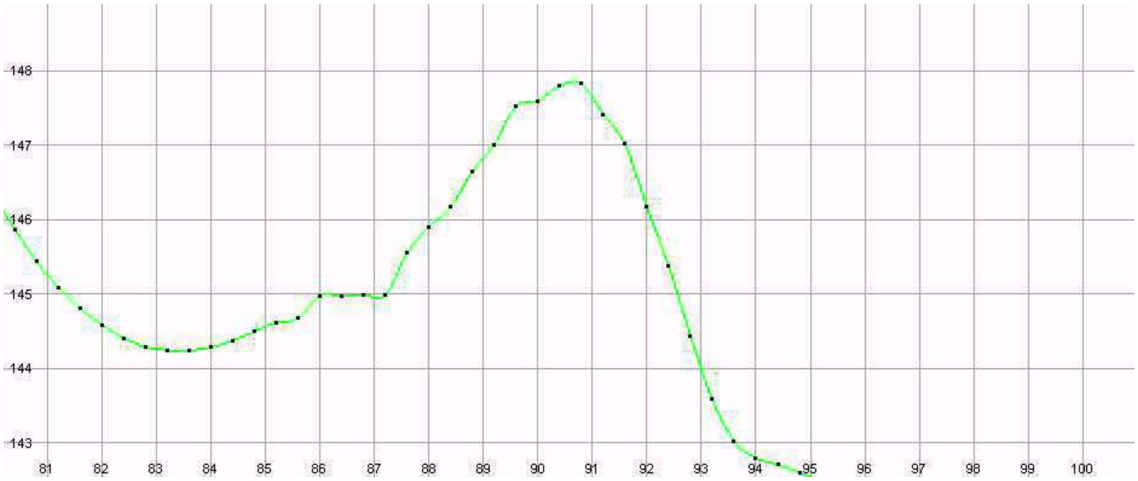


As the previous sequence of images shows, the input value to the Butterworth filter noticeably changes the result. The first example, a frequency input of 3, shows a lot of smoothing applied to the curve while the last example shows very little change to the curve. Depending on your needs, these might be appropriate levels of change. For most purposes, however, values between 6 and 12 work very well as can be seen in the middle two images. In these two examples, the noisy part of the data has been removed while the overall characteristics of motion have been retained.

3-Point Average and 5-Point Average Filters

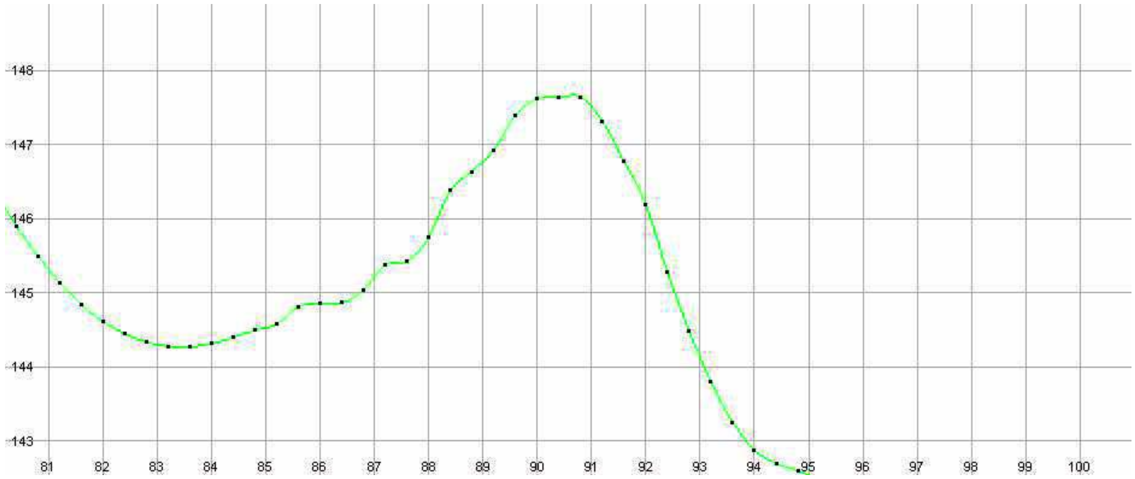
Two other filters, the 3 Point Average and the 5 Point Average filter are provided as an alternative to the Butterworth filter. In some circumstances (particularly with facial data), these can provide better results. The 3 Point Average smooths the data by taking a data point on either side of a given, original data point and averaging their values into the original one to create a new data value for that sample. This filter provides a moderate amount of smoothing as shown below:

Figure 10-9. The Curve After an Application of the 3 Point Average Filter



The 5 Point Average filter works just like the 3 Point Average filter except that it uses 2 data points on either side of the original data point to produce a new value. Since the width of the filter is wider the results are more aggressive which creates more smoothing, as seen here:

Figure 10-10. The Curve After an Application of the 5-Point Average Filter



The type of smoothing you choose depends on your needs and how much (and in what way) you want to change your data. It is perfectly reasonable to make successive applications of the filter(s) to affect the data in various ways. The number of possible combinations are extremely high so some experimentation will be necessary to find the right one for you.

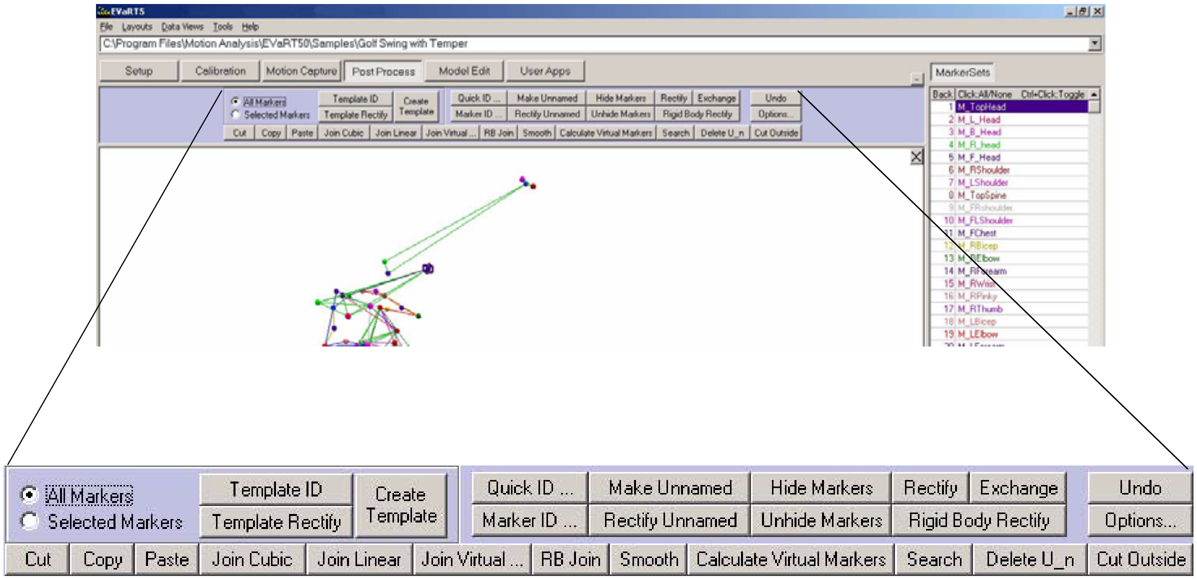
Unnamed Markers

Unnamed markers are defined as unidentified markers that are either real or not real. Some unnamed markers represent good data, yet were unidentified during a motion capture session. Others are called ghost markers and should be deleted. Ghost markers can also be removed from future data captures by going to the Tracking sub-panel in Motion Capture, and setting the **Min. Cameras to Use** (minimum number of cameras to use) to **3**.

Note: Caution should be taken here as this process may also eliminate good data.

Post Process Toolbar

Figure 10-11. Post Process Toolbar


EVaRT5
File Layouts Data Views Tools Help
C:\Program Files\Motion Analysis\EVaRT50\Samples\Golf Swing with Temper
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
MarkerSets
All Markers
Selected Markers
Template ID
Template Rectify
Create Template
Quick ID ...
Marker ID ...
Make Unnamed
Rectify Unnamed
Hide Markers
Unhide Markers
Rectify
Exchange
Rigid Body Rectify
Undo
Options...
Cut
Copy
Paste
Join Cubic
Join Linear
Join Virtual ...
RB Join
Smooth
Calculate Virtual Markers
Search
Delete U_n
Cut Outside

All of the Identifying tools are accessible using hot keys, panel buttons, and right mouse menu items on the 3D Display and XYZ Graphs.

All Markers Radial Button	Allows you to select all markers at once for Identifying.
Selected Markers Radial Button	Allows you to select specific markers for Identifying.
Template ID	Uses the template to ID all markers in the current frame.
Template Rectify	Uses the template and continuous tracks to ID markers thorough time.
Create Template	Refer to "Building a Template" on page 9-5.
Make Unnamed	Make Unnamed will specifically move a marker's data into the first unnamed marker slot. It is important to know that the data is not deleted by this operation.
Rectify Unnamed	Makes unnamed markers into contiguous paths to follow through the capture sequence. For more information on the Rectify functions, refer to "Rectify Functions: What They Do and When To Use Them" on page 10-15.

Quick ID

Identifies the selected marker, identifying all markers one by one, according to the list. It will normally select with auto incrementation (Auto Increment).

Marker ID

Marker ID is the same as Quick ID, without the auto increment feature.

Exchange

Exchanges the XYZ coordinates of two selected markers.

Hide Markers

Hides selected 3D view markers.

Unhide Markers

Unhides the hidden selected 3D view markers.

Rectify

Re-identifies missing makers (gaps) in a determined frame range. For more information on the Rectify functions, refer to “Rectify Functions: What They Do and When To Use Them” on page 10-15.

Rigid Body Rectify

Uses the selected markers to ID unnamed markers through the capture sequence. For more information on the Rectify functions, refer to “Rectify Functions: What They Do and When To Use Them” on page 10-15.

Rigid Body Rectify and Template Rectify assume that all the current marker identifications are correct. They are intended for continuing the identification process without undoing previous work.

Rigid Body Rectify is a tool that could be considered a "stand-alone" tool. It does not use anything from the marker set definition at all. When the tool is activated:

1. The selected markers are dynamically turned into a "Rigid Body" definition and measured
2. The previous frame and the current frame are then used to predict the next frame
3. Identify the frame

This stops when less than three markers of the original selected markers is identified.

Note: If one or more markers are already correctly identified, then that can help prevent errors.

This has been used to identify the entire body.

1. Select ALL the markers (minus the obscured ones). The starting frame must be identified manually.
2. Press **Rigid Body Rectify**
3. Go forward to the frame where the misidentification occurred
4. Make unnamed
5. Repeat steps 2 through 5.

Options

Sets the sliders, zoom, and search options.

Rectify

Used for cleaning up the Initial Pose for making a template when you have no template to start with. Takes ALL markers on the current frame (regardless of the All vs. Selected radial button), measures the linkages on the current frame and uses those measures to automatically sort markers into the correct marker slots.

Characteristics of Rectify:

- Uses all markers, Named and Un-named
- Works only on the Highlighted XYZ Selected Time Range
- Uses the Named marker linkages and XYZ path continuity
- It will switch Named markers (Named markers are not automatically locked)
- Adjusts Linkage lengths dynamically to fit the data (including mistakes)
- Uses the **Motion Capture > Tracking > Identifying Parameters** function (typical)

Cut

Cuts the data within the selected frames inclusive of the endpoints.

Copy

Copies selected markers in selected frames.

Paste

Pastes data with the Current Frame being the first frame of the paste region.

Cut Outside

Cuts the data outside of the selected frames exclusive of the endpoints.

Smooth

Smooths data within the set frames with the selected filter type. The filter selection is found in the **Post Process > Options** form. For more information, refer to "Filters" on page 10-4.

Calculate Virtual Markers

This calculates the virtual markers based on the parameters set. For more information, refer to "Virtual Markers" on page 11-6.

Join Cubic

Calculates the values to place in the gaps with a cubic spline. If you manually select the endpoints of the gap before executing the join, the function will fill the gap with a linear interpolation because the second derivative at the endpoints equals zero.

Join Linear

Selecting this will automatically fill the gap with linearly interpolated data.

Join Virtual

For all information regarding Join Virtual, refer to See "Join Virtual" on page 10-22.

Exchange

Exchange requires that exactly two markers are selected. The data is exchanged between the markers within the selected frames.

Search

Finds gaps and/or spikes throughout the data set. The current frame will be set to the first gap or spike found in either the first selected marker on the marker list or all of the markers. See the Post Options form for settings.

Delete U_n

Deletes all unnamed markers.

Options

The Options button opens a form that lets you set the sliders, zoom, undo, and search (for gaps and/or spikes) options.

The Acceleration at Spikes function will indicate the frames in which a marker has experienced an acceleration greater than or equal to the selected value. The indicator appears as a carat (V) at the top of the XYZ Graphs.

The Memory Gauge lets you know when you computer is running out of memory to store edits in the undo buffer.

RB Join

The rigid body join feature has been created for rigid objects with 4 or more markers per segment. For rigid or semi-rigid objects such as swords, spears, head markers, torso markers, multiple markers on a basketball, it is convenient to use this feature to join across missing marker data. You must select a starting frame where all markers that you select are all present and part of a rigid body. You then select a range of frames on which you wish this to operate. Select **RB Join** and it automatically joins across the missing marker data.

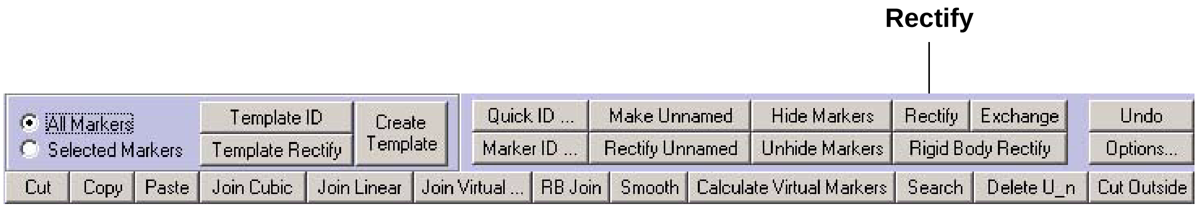
Undo

Undo retrieves data affected by the most recent Edit or ID function and places it back into the data set. **EVaRT** supports ten levels of undo. This feature can be disabled or cleared on the Post Options form. If you get the message that an Undo function may not execute, you may need to clean your Undo buffer. This can be found in the **Post Process > Options > Undo** section.

Rectify Functions: What They Do and When To Use Them

There are three main Rectify tools for naming markers and propagating the names through time (Rectify, Rectify Unnamed, and Rigid Body Rectify). They are not for generating XYZ data from the 2D camera views, which we call Tracking, but they are very useful for Identifying the tracks or markers. Rectify means to “make right” or “set right”. All of the Rectify functions start at the Current frame and go forward in time first, then backwards from the current frame.

Figure 10-12. Post Process Toolbar Buttons


Rectify
● All Markers
○ Selected Markers
Template ID
Template Rectify
Create Template
Quick ID ...
Marker ID ...
Make Unnamed
Rectify Unnamed
Hide Markers
Unhide Markers
Rectify
Exchange
Rigid Body Rectify
Undo
Options...
Cut
Copy
Paste
Join Cubic
Join Linear
Join Virtual ...
RB Join
Smooth
Calculate Virtual Markers
Search
Delete U_n
Cut Outside

Rectify

Used for cleaning up the Initial Pose for making a template when you have no template to start with. Takes ALL markers on the current frame (regardless of the All vs. Selected radial button), measures the linkages on the current frame and uses those measures to automatically sort markers into the correct marker slots.

Characteristics of Rectify:

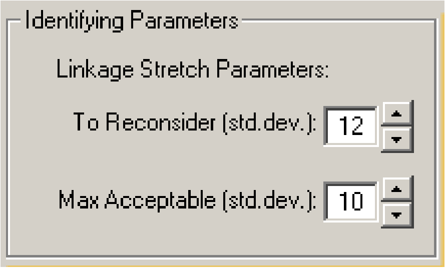
- Uses all markers, Named and Un-named
- Works only on the Highlighted XYZ Selected Time Range
- Uses the Named marker linkages and XYZ path continuity
- It will switch Named markers (Named markers are not automatically locked)
- Adjusts Linkage lengths dynamically to fit the data (including mistakes)
- Uses the **Motion Capture > Tracking > Identifying Parameters** function (typical)

Motion Capture > Tracking > Identifying Parameters: Details

To Reconsider

If a link stretches more than the set amount, the path is snipped into two paths where the link stretches too much. This happens if markers come together and pull apart and the identity is not correct when they pull apart. The software may not see it right away, but after a few frames, the linkage for the wrongly named markers get too long and the path is cut. The bigger the number, the more the link is allowed to stretch before it is cut. Smaller means fewer errors, more cuts. Larger means more stretching is allowed before the cuts. It is measured in multiples of the standard deviation of the linkage length to make it accommodate linkages that normally change a lot (head to shoulder) and linkages that do not change much (elbow to wrist). Also used in Real Time streaming (Run) mode.

Figure 10-13. Linkage Stretch Parameters



Identifying Parameters

Linkage Stretch Parameters:

To Reconsider (std.dev.): 12

Max Acceptable (std.dev.): 10

Max Acceptable

If there is a missing marker and there is an Un-named marker within this distance of known linkages, the Un-named marker is accepted as a Named marker. Also used in Real Time streaming (Run) mode.

Template Rectify

In Post Processing, use this when you have a reasonably good template. Work from known good frames into unknown and difficult frame ranges. Uses the template from the Create Template item. A template can be of one or more frames, should represent characteristic motions to be seen between markers, and is a measure of the min. and max. linkage lengths for Named markers.

The characteristics of Template Rectify are as follows:

- Uses only the Template information to move markers from the Unnamed slots to the Named slots
- Uses All Markers or Selected Markers according to the setting, as shown in Figure 10-13.
- Works only on the highlighted XYZ selected time range, starting on the current frame going forward, then backward from the current frame
- Protects all named markers, will not switch them

- Works only to move Un-named markers into the Named marker slots—here, all markers are locked
- Does not use Linkage Stretch Parameters in **Motion Capture > Tracking**

Rigid Body Rectify

In Post Processing, it is used when you have bodies crashing into each other where linkage lengths can get very distorted and Template Rectify can give results which may require some editing. Rigid Body Rectify is for very tough trials where you can have the software look for a rigid body with markers on it and it tends not to make mistakes and hence does not require a lot of editing after the fact. Work from a frame with known marker IDs to difficult areas. A Rigid Body can be any set of 3 or more Selected Markers. The software measures the markers with respect to each other and looks for this pattern in the Un-named marker to automatically assign them names. It will stop if either of two conditions are met:

1. It cannot find at least 3 of the markers of the Rigid body on a frame (so use more than 3 marker if you can)
2. The measurements stretch too much

It can be re-started on a new frame if needed. The selected markers must be identified on the Starting Frame.

The characteristics of Rigid Body Rectify are as follows:

- Measures all markers in the selected Rigid Body on the Starting Frame
- Uses All or Selected Markers (mostly used for Selected Markers)
- Protects all named markers, will not switch them.
- Works only to move Un-named markers into the Named marker slots—here, all the markers are locked
- Does not use Linkage Stretch Parameters in **Motion Capture > Tracking**

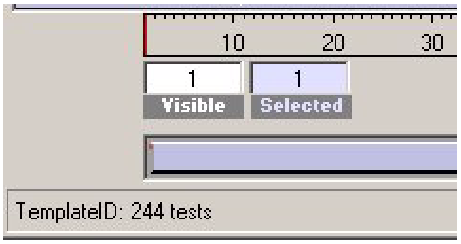
Rectify Unnamed

Rectify Unnamed sorts the Un-named slots into continuous paths based on path continuity, similar to the tracking function. No templates or linkages are used. Path segments separated by 10 or more frames are considered to be separate paths and will not necessarily be continuous. This is used to clean up the Unnamed path segments and can make the Marker ID function work more smoothly. It means you may not need the Rectify Always On check box in Marker ID and Quick ID Items. First try the Rectify Unnamed function, then try the Marker ID function for the problem areas.

Template ID

Uses the currently defined Template from Create Template to fit the linkages into the current frame's marker cloud. If it succeeds, it tells you the number of tests on the Status Bar (lower left side of the screen) it took to complete. It may also fail or time-out, in which case you should make sure all of the markers are present on the current frame or perhaps remake your template. It only changes data on the current frame if it is successful. You can then use Template Rectify to get the correct IDs to other frames.

Figure 10-14. Template ID Details



TemplateID: 244 tests

How good is the Template? You can tell how good your template is by how many tests it takes for the Template ID function to work. A low number means it is working quickly (low is say 500). A high number (5,000 or more) means the software has to try very hard to ID the current frame. It stops trying after about 50,000 tries in Connect (Live) mode and "times out" and gives the message `Template ID: Timed out`. In Post Processing mode, it will not time out until 500,000 tries. That means it did not get to try out all possible linkages. A large number indicates a potential problem. It might be because the current frame is stretched beyond the template or in a much different actor position, or it might be because the Template is not very good. Try to use the Template ID on different frames and see if the number changes a lot. If you consistently get large numbers for the Template ID feature, try adding more links to your marker setup in the Model Edit panel.

Make triangles, especially triangles that will be fairly rigid during the movements. Lots of rigid triangles in your linkages make for solid Templates that have fast Template ID numbers. Triangles with equal sides can cause mis-IDs whereas triangles with unequal sides work much better. This will help to determine where to place markers on a person.

You must have all of the markers present on the current frame or you will get the status bar message `Template ID failed.` That means it did try out all possible linkages and could not get a match. Possibly the markers have moved or you need a better template.

Summary of When To Use What

Rectify

First, collect the trial from which you will make your template. It should be a simple trial with representative motions and not require any editing. The goal is to represent the min. and max. of each linkage in your model. Use Quick ID, then Rectify**.** If editing is required, consider taking another trial. Make sure there are no marker switches using the 3D and XYZ view, and then create a template using all of the (good) frames. Rectify may generate marker switches and you do not want those remembered in the template. It will haunt you later.

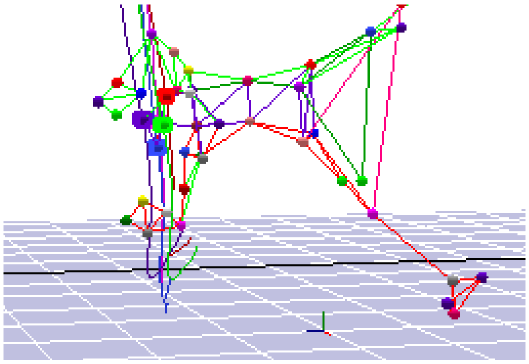
Template Rectify

For most motion trials, the use of Template Rectify will do most of the work in correctly identifying the marker tracks. Template Rectify is preferred method to use to rectify since it protects the named marker tracks: they are locked. It also keeps the template rigid and seems less likely to make mistakes. Correcting mistakes can take a lot of time. If there are some incorrectly ID-ed markers, it may be best to make all the markers Unnamed for all except the starting frame (which can be frame 1 or any other frame). To make all unnamed except frame 1, go to frame 2, select **All Markers,** then select the time range: Select **Forward**, and press **Make Unnamed** under the Identifying tab. Go back to frame 1 and press **Template Rectify.** On some complex trials where there is a crash or bang between people and or props, have the actors start in the T-pose, do the actions and return to the T-pose. You can then work the data from the start to the middle and also from the end to the middle. This working the data back and forth can save a lot of your time and not require that you hand ID many frames.

More on Templates and Template ID

After a big crash of people with markers or extreme movement, the markers may have moved and the template may not be as good. You can Extend the template by ID-ing after the crash, extend it based on one or more frames that have no mistakes, then try Template ID to see if the template holds on the new frames. Template ID tells you how good the template is working and it is the same template the Template Rectify uses. Also, think that Template Rectify gets used as much to un-identify tracks as well as identify them. If any link stretches beyond the allowable range (plus a small amount of give), then Template Rectify will cause the offending marker or markers to become unnamed, while it seems perfectly obvious to you what is right. If Template Rectify does this, manually ID that marker on that frame and Extend the Template (an option under the Create Template button). You can see this when the subject bends over and causes stretches that might not have been recorded when creating the template.

Figure 10-15. Template ID and Rectify Used for Link Stretch



Rigid Body Rectify

This takes the most time to use in that you must select a few markers and process a few frames, then repeat the process over the possibly many segments and frame sequences. If it stops, it means that the rigid body disappeared. You can re-start it again and it starts with new measurements on the starting frame. Where it is very useful is where it can slug through some tough sequences. Start with something simple, like the 3 or 4 or 5 markers on the head. As with Template Rectify, it may be best to Make Unnamed all markers on all frames if there are any mistakes in the ID-ed data. If one of the head markers is incorrectly ID-ed as a neck marker, then Rigid Body Rectify will not see that as a candidate since it only looks in the Unnamed markers list. Process the data from both ends towards the difficult part, assuming there is a “crash” in the middle and clean data on both ends. After doing Rigid Body Rectify from the starting frames to the middle, then from the ending frames to the middle, use Template Rectify to go it again. For difficult data trials, this 1-2-3-4 combination will get you a lot of named markers for very little work.

Correctly Identifying Markers Automatically: Post Processing Mode

In the **Post Process** panel, the data is identified (or re-identified) by pressing the **Template Identify** button. This affects the current frame only and it is successful if:

1. The template is good and the data fits.
2. All markers are present.

To continue the correct identification to successive frames, you need to have the Max. Speed and Max. Prediction Error settings correctly set for your data.

Max Speed (mm/frame)

This applies to when a marker first appears and is identified with the current template. To keep the correct identity into the next frame, the software checks to see if it has moved too much to be the same marker. It can move in any direction. The Max Speed parameter tells how much movement is allowed. It is measured in mm from the first frame, hence the units of mm/frame. If no marker is seen within this search sphere, then the target identify is not continued into the next frame. If a marker is found within the Max. Speed sphere, the target identity is continued into the second frame. If the number is set too small, tracking will slow down as the software tries unsuccessfully to find continuations of markers. This affects the first to second frame tracking time especially. If the number is set too big, you will see markers switch identities.

Max. Prediction Error (mm)

After a marker has a history of 2 or more frames of continuous identity in time, a track history allows the software to predict where the marker should be, based on a 2nd degree polynomial prediction. The software looks in a search radius of the Max Predictor Error about the predicted location for a continuation of each marker being tracked. The Max Prediction Error is usually set to about one-half of the Max. Speed parameter.

Join Virtual

Join Virtual is an extremely powerful editing tool used to fill gaps in marker data with simulated data based on the relationship (positional interpolation) with other markers on or near the particular problem segment. This accurately simulated information is a result of making four passes over the data in both Real Time and Post-Processing modes.

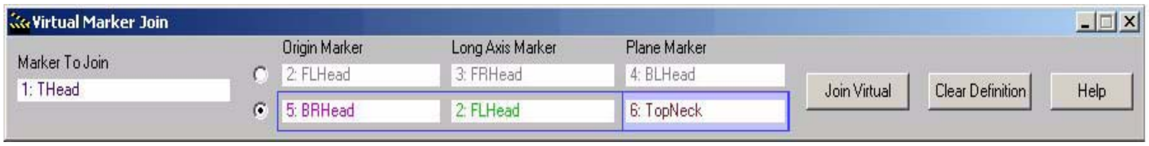
To use the Join Virtual function:

1. Find a gap within the position data of a marker. It is easiest to use the Search function (right click in XYZ Graphs and select Search).

   If you are not using the Search function, select the gap area in the XYZ Graphs (middle-click and drag) for the problem marker.

2. Select **Join Virtual** in the **Post Process** panel. Verify that the Marker to Join is set for the marker you want to edit.

Figure 10-16. Join Virtual (Virtual Marker) Definitions



Marker To Join		Origin Marker	Long Axis Marker	Plane Marker
1: THead	○	2: FLHead	3: FRHead	4: BLHead
	●	5: BRHead	2: FLHead	6: TopNeck

3. Click on **Origin Marker**. It will be highlighted in blue and will allow you to choose which marker to use as the marker that is most rigidly attached to the marker to join. See “Origin Marker” on page 10-23.

Note: Select markers using the 3D Display or the marker grids.

4. The function will then automatically jump to the Long Axis Marker input box. Continue selecting the proper markers for each remaining input box. Make sure they are all different. You cannot have two of the same markers in the Virtual Marker Join definitions.
5. Once you have defined the three definition markers for you Virtual Marker, click on **Join Virtual**.

Note: If data is missing for any definition marker (Origin Marker, Long Axis Marker, Plane Marker) in the frame field, the gap in data will not be completely filled. You will need to select a different definition marker that has data for that frame field.

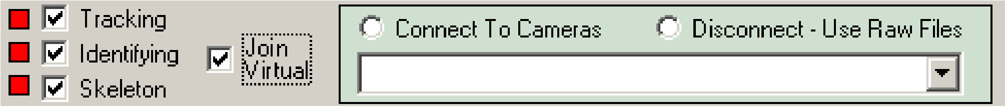
6. Repeat step 1 through step 5 for all problem markers in your data set. You may also setup the Virtual Marker definitions for as many markers as you feel will be needed, prior to capture.
7. Selecting File > Save Project will save all Virtual Marker definitions you have set into the project file.

Real Time Streaming with Join Virtual Fill

If you will be continuing to capture motion using the same template, the Virtual Marker Join definitions are now resident with the project files and template. The Join Virtual check box can now be activated (on the Real

Time Dashboard) allowing for Virtual Markers to be created in Real Time where data is missing for the markers you have set definitions. Thus, streamlining the editing process or post processing tasks.

Figure 10-17. Join Virtual Check Box



The concept behind the Join Virtual and the Virtual Marker definitions are the same and are much more stable and more useful than the classic Rigid Body data filling mechanisms. The reason is that you get to choose three markers in decreasing importance that determine the replacement data. These three markers are:

1. the Origin Marker
2. the Long Axis Marker
3. the Plane Marker

Origin Marker

The Origin Marker should be the marker that is most rigidly attached to the marker to join. If there are two choices, pick the one that is more stable on the bone segment. For example, the elbow marker is a good Origin Marker. It is usually attached close to a bone. The shoulder is also good for the upper arm segment, but not as good for the upper torso if the subject raises their arms.

For segments where you have multiple markers on a rigid segment, such as the head, it does not matter which marker is which. For example, if you have four markers on the head, each of the four can be defined by any order of the other three markers. But if you have only three markers on the head, the Top_Neck marker may well be used as the Plane marker for the Join Virtual definitions.

Long Axis Marker

The Long Axis Marker defines a straight line from the Origin Marker and the Join Virtual is not sensitive to changes in the length of this line.

Long Axis Marker Example

For the left Biceps, choose the L_Elbow as the Origin, the L_Shoulder as the Long Axis Marker, and the L_ Wrist as the Plane Marker.

Plane Marker

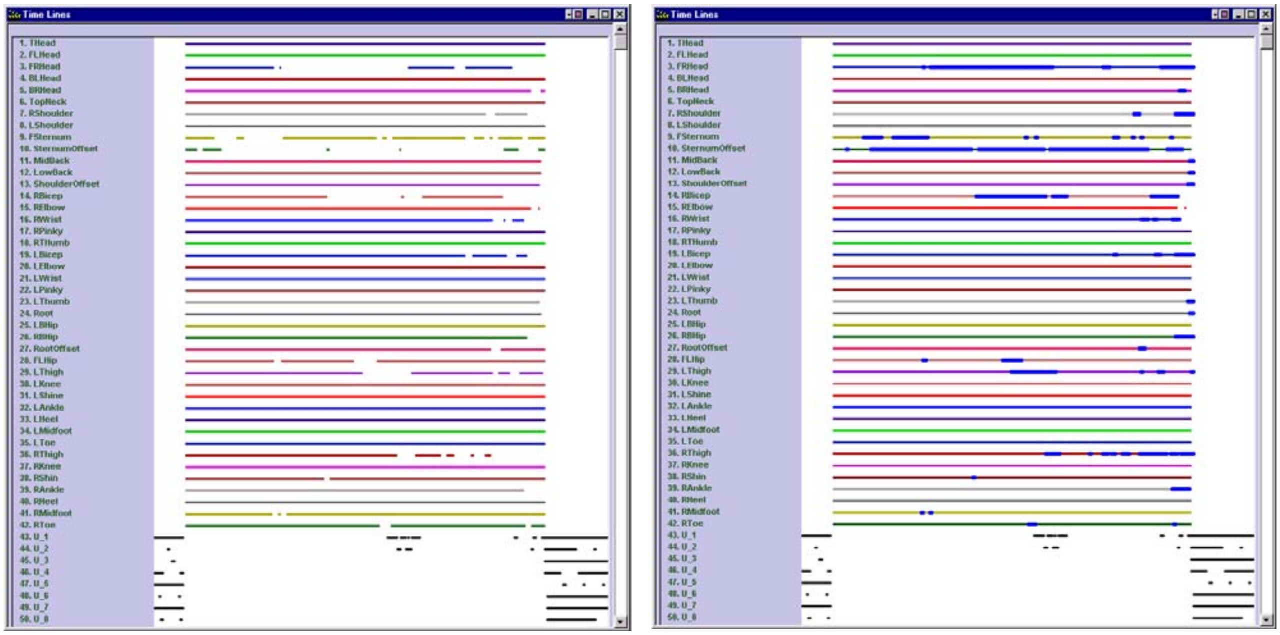
The Plane Marker is the least strongly coupled marker to the problem marker to Join. It defines only the rotation of the coordinate system located at the origin. Join Virtual and Virtual Marker calculations use the 3D offsets from the problem marker to the coordinate system’s Origin Marker and apply that throughout the Join Virtual.

The results are often astoundingly good and can be used directly to speed up your animation pipelines. More study is recommended before applying these results to Biomechanics research and medical applications.

In short:

- The **Problem Marker** is the marker with the gap to be filled.
- The **Origin Marker** maintains a fixed distance to the problem marker.
- The **Long Axis Marker** defines a line to the origin marker.
- The **Plane Marker** defines a plane with the Origin and Long Axis Markers.

Figure 10-18. TRC File vs. TRB File With Join Virtual



TRC file—no Join Virtual

TRB file from same data set with Join Virtual

Time Lines
1. THead
2. FLHead
3. FRHead
4. BLHead
5. BRHead
6. TopNeck
7. RShoulder
8. LShoulder
9. FSternum
10. SternumOffset
11. MidBack
12. LowBack
13. ShoulderOffset
14. RBicep
15. RElbow
16. RWrist
17. RPinky
18. RThumb
19. LBicep
20. LElbow
21. LWrist
22. LPinky
23. LThumb
24. Root
25. LBHip
26. RBHip
27. RootOffset
28. FLHip
29. LThigh
30. LKnee
31. LShine
32. LAnkle
33. LHeel
34. LMidfoot
35. LToe
36. RThigh
37. RKnee
38. RShin
39. RAnkle
40. RHeel
41. RMidfoot
42. RToe
43. U_1
44. U_2
45. U_3
46. U_4
47. U_5
48. U_6
49. U_7
50. U_8

To test the operation of this feature, define a Virtual Marker Join for the RHip marker based on 3 others that will remain visible. Cover the RHip marker (for example) and see if it appears in the 3D view. This can be done with a live person very easily, but if you do not have a setup available, go to the 2D view of a trial, mask out enough regions and cameras so that the RHip is no longer visible. It should appear in the 3D view if you turn on the Join Virtual feature.

Both the streaming and the post-process Join Virtual use a two-pass process to virtually join data across gaps. The data passes through the Virtual Marker Join function twice, with the second pass using filled or partially filled gaps that were not filled the first time.

Join Virtual Guidelines

Note: These guidelines are intended for an audience with a good knowledge of motion capture theory and practice. These are generalized guidelines only. Individuals may find that different definitions may work better for their particular applications.

For best results, it is recommended that you have at least three markers per effected segment. Ideally, for markers that have the possibility to become obscured (i.e. being covered up or lost between the ground and the subject’s body) you will need to place markers on the opposite side of the appendage or body. For example, if a subject is laying prone on the floor, the back markers become obscured. If you anticipate this, you can apply more markers to the chest or front torso area.

For defining virtual markers, when possible, define and use markers that are always seen on that segment or neighboring segments.

If any data is missing from other markers in that segment, the original data will improve, but only if the dependent markers are present.

Head

A subject’s head usually will have four or five markers. Missing marker data for the head is joined using Join Virtual definitions with any three of the other markers.

Upper Arm or Upper Leg

Typically the upper arm segment is defined by three markers: Elbow, Biceps, and Shoulder. Ideally, a fourth marker on the Triceps would be present. If not, a marker on the forearm can be used as the plane marker for Join Virtual data.

If the shoulder data is missing, you may use the markers for the top of the neck, sternum, or mid-back to calculate the Virtual Marker data for the shoulder.

Hand or Foot

If you know of movements that are going to obscure the markers on a hand or foot, you may want to set redundant markers on that particular segment.

For example, if all lateral side markers on a foot are obscured from a subject laying down in a prone position, you may apply redundant markers to the medial side to provide the data for that segment.

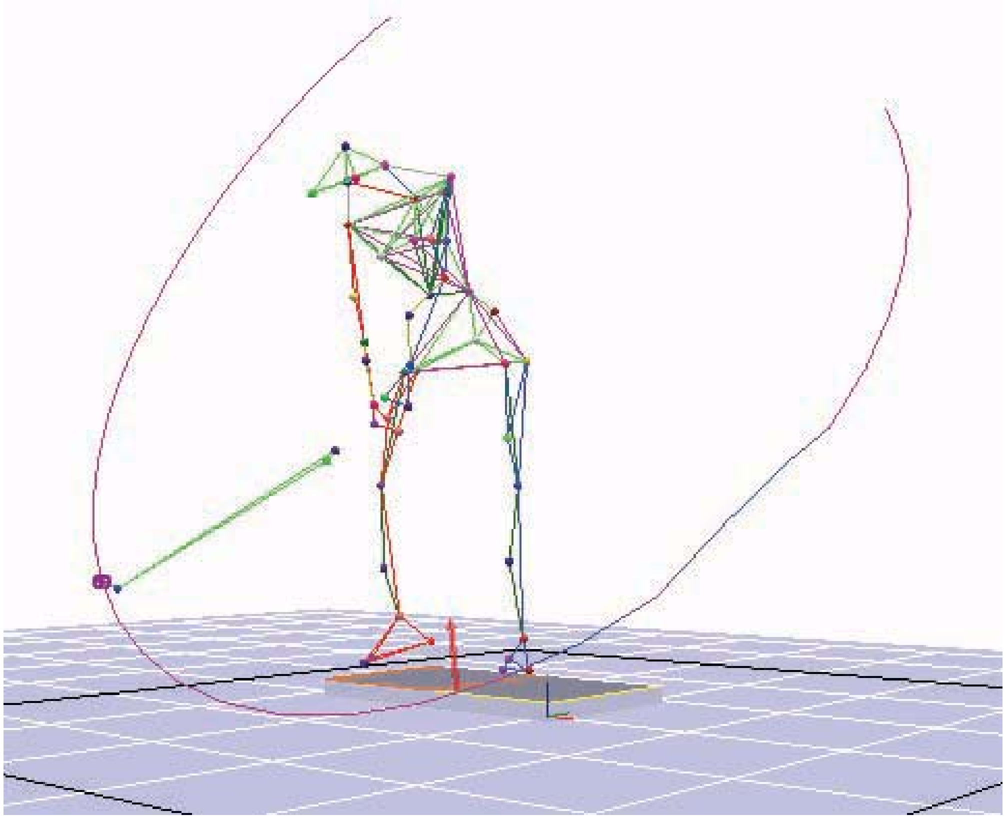
The hand will use the same technique, with maybe a few less redundant markers on the opposite side.

For an example of a project with Join Virtual definitions for all markers, see the **6Eagle_VirtualJoin** directory in **C:\Program Files\Motion Analysis\EVaRT50\Samples.**

Data Painting

Data Painting allows you to directly manipulate the data in the XYZ Graphs pane. Simply press **Ctrl** + **Shift** and left-click to modify or add data directly on the screen.

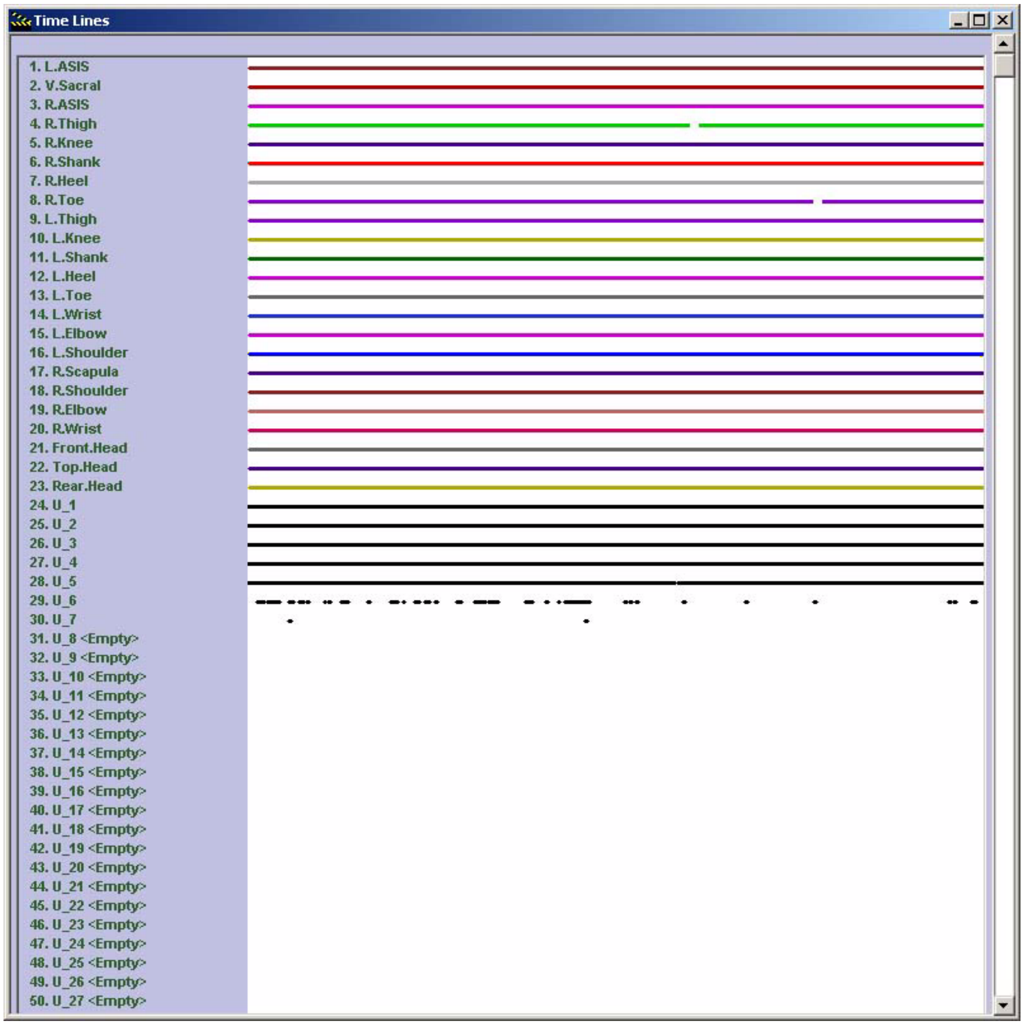
Figure 10-19. Data Painting



Time Lines

In the Menu Bar, select **Tools > Time Lines**. Time Lines provide a general overview of the quality of the data in the marker slots, showing any breaks in the stream of data for all markers.

Figure 10-20. Time Lines



1. L.ASIS
2. V.Sacral
3. R.ASIS
4. R.Thigh
5. R.Knee
6. R.Shank
7. R.Heel
8. R.Toe
9. L.Thigh
10. L.Knee
11. L.Shank
12. L.Heel
13. L.Toe
14. L.Wrist
15. L.Elbow
16. L.Shoulder
17. R.Scapula
18. R.Shoulder
19. R.Elbow
20. R.Wrist
21. Front.Head
22. Top.Head
23. Rear.Head
24. U_1
25. U_2
26. U_3
27. U_4
28. U_5
29. U_6
30. U_7
31. U_8 <Empty>
32. U_9 <Empty>
33. U_10 <Empty>
34. U_11 <Empty>
35. U_12 <Empty>
36. U_13 <Empty>
37. U_14 <Empty>
38. U_15 <Empty>
39. U_16 <Empty>
40. U_17 <Empty>
41. U_18 <Empty>
42. U_19 <Empty>
43. U_20 <Empty>
44. U_21 <Empty>
45. U_22 <Empty>
46. U_23 <Empty>
47. U_24 <Empty>
48. U_25 <Empty>
49. U_26 <Empty>
50. U_27 <Empty>

Analysis Graphs

The Analysis graphs and their related control panel provide tools to analyze your realtime and post process data. This window has three tabs which calculate data for the following:

- Position, velocity, and acceleration
- Distance between markers
- Included angles

The Analysis graphs are activated by pressing the **F7** key.

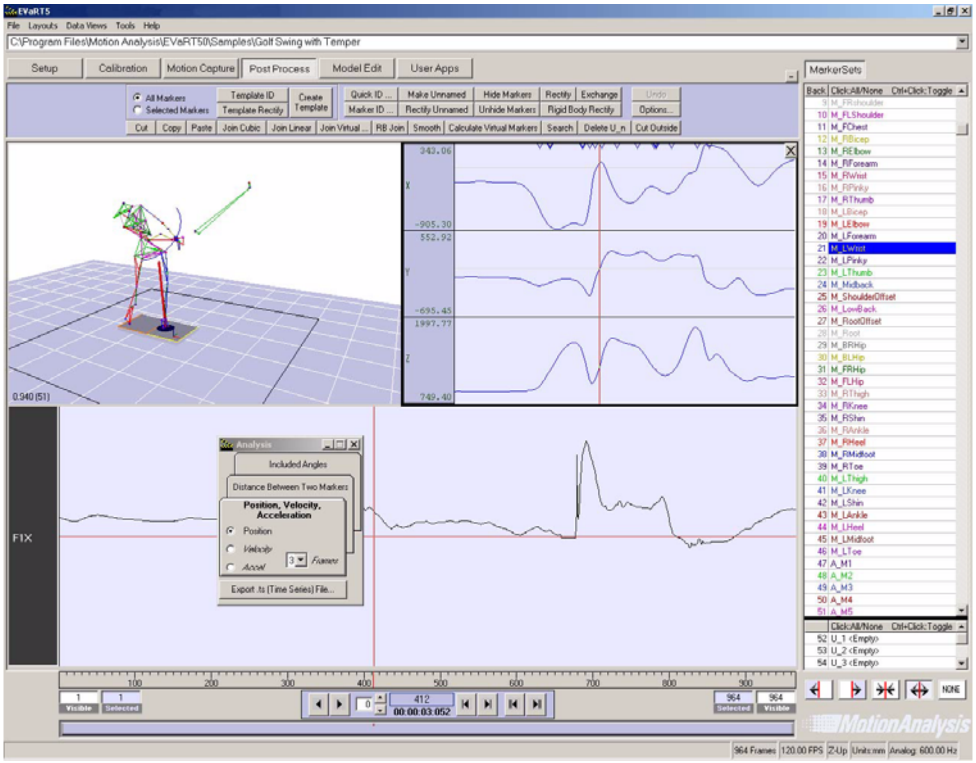
Position, Velocity, and Acceleration Tab

This tab creates graphs of the position data, calculated velocity data, or calculated acceleration data for up to 10 selected markers.

Note: Any number of marker data can be exported.

The number of frames used to calculate the velocity and acceleration data is set by the user. The number of frames used can be either 3, 5, 7, or 9. Using the higher number of frames to calculate the data will result in smoother output through noise reduction.

Figure 10-21. Position, Velocity, and Acceleration Tab

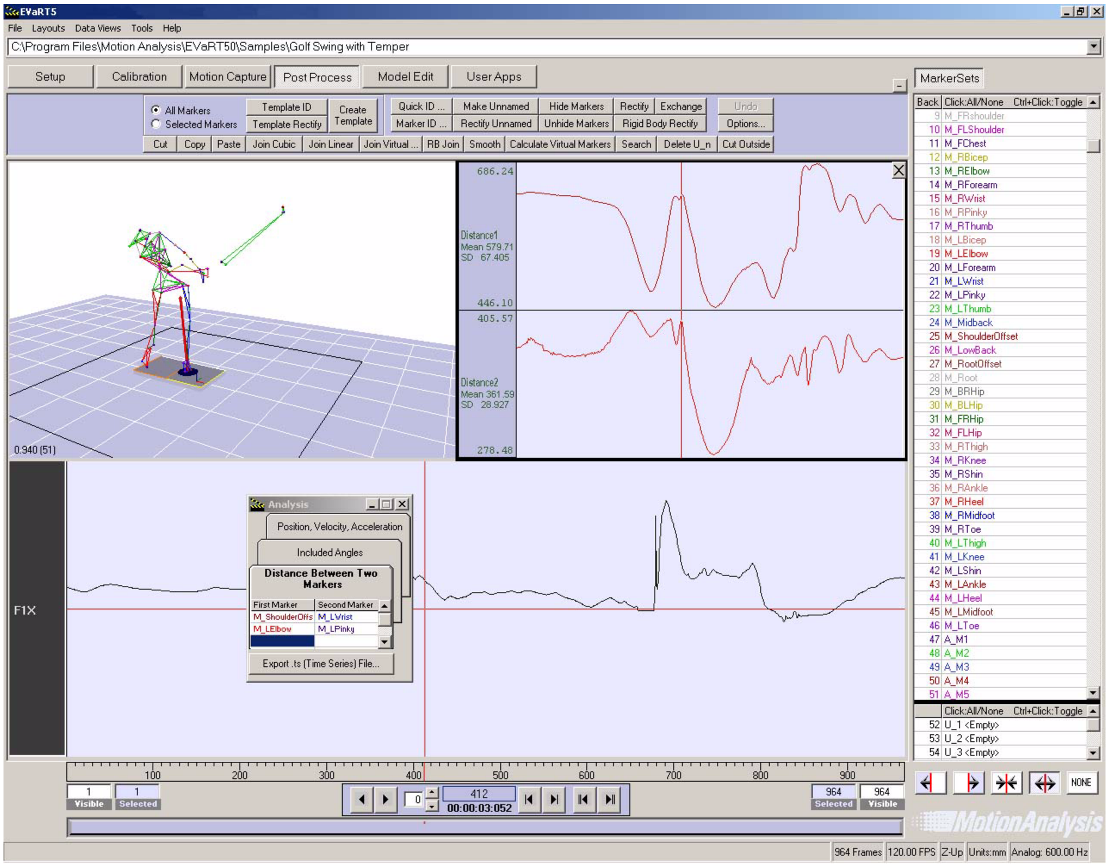

EVaRT5
File Layouts Data Views Tools Help
C:\Program Files\Motion Analysis\EVaRT50\Samples\Golf Swing with Temper
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
MarkerSets
All Markers
Selected Markers
Template ID
Template Rectify
Create Template
Quick ID ...
Marker ID ...
Make Unnamed
Rectify Unnamed
Hide Markers
Unhide Markers
Rectify
Rigid Body Rectify
Exchange
Undo
Options...
Cut
Copy
Paste
Join Cubic
Join Linear
Join Virtual ...
RB Join
Smooth
Calculate Virtual Markers
Search
Delete U_n
Cut Outside
343.06
X
-905.30
552.92
Y
-695.45
1997.77
Z
749.40
0.340 (51)
FIX
Analysis
Included Angles
Distance Between Two Markers
Position, Velocity, Acceleration
Position
Velocity
Accel
3
Frames
Export .ts (Time Series) File...
100
200
300
400
500
600
700
800
900
1
Visible
1
Selected
0
412
00:00:03.052
964
Selected
964
Visible
NONE
MotionAnalysis
964 Frames
120.00 FPS
Z-Up
Units:mm
Analog: 600.00 Hz
Back
Click:All/None
Ctrl-Click:Toggle
9 M_FRshoulder
10 M_FLShoulder
11 M_FChest
12 M_RBicep
13 M_RElbow
14 M_RForearm
15 M_RWrist
16 M_RPinky
17 M_RThumb
18 M_LBicep
19 M_LElbow
20 M_LForearm
21 M_LWrist
22 M_LPinky
23 M_LThumb
24 M_Midback
25 M_ShoulderOffset
26 M_LowBack
27 M_RootOffset
28 M_Root
29 M_BRHip
30 M_BLHip
31 M_FRHip
32 M_FLHip
33 M_RThigh
34 M_RKnee
35 M_RShin
36 M_RAnkle
37 M_RHeel
38 M_RMidfoot
39 M_RToe
40 M_LThigh
41 M_LKnee
42 M_LShin
43 M_LAnkle
44 M_LHeel
45 M_LMidfoot
46 M_LToe
47 A_M1
48 A_M2
49 A_M3
50 A_M4
51 A_M5
Click:All/None
Ctrl-Click:Toggle
52 U_1 <Empty>
53 U_2 <Empty>
54 U_3 <Empty>

Distance Between Two Markers Tab

The Distance Between Markers tab shows the distance between two selected markers for each frame throughout the tracked data. You may select any two markers in the tracked data to be analyzed by clicking those markers in the 3D Display or on the marker list grids.

To delete a pair of markers from the grid, click on the row and press the **Delete** key. You may select and delete several rows at once by pressing **shift + click** on the rows and pressing **Delete**.

Figure 10-22. Distance Between Two Markers Tab

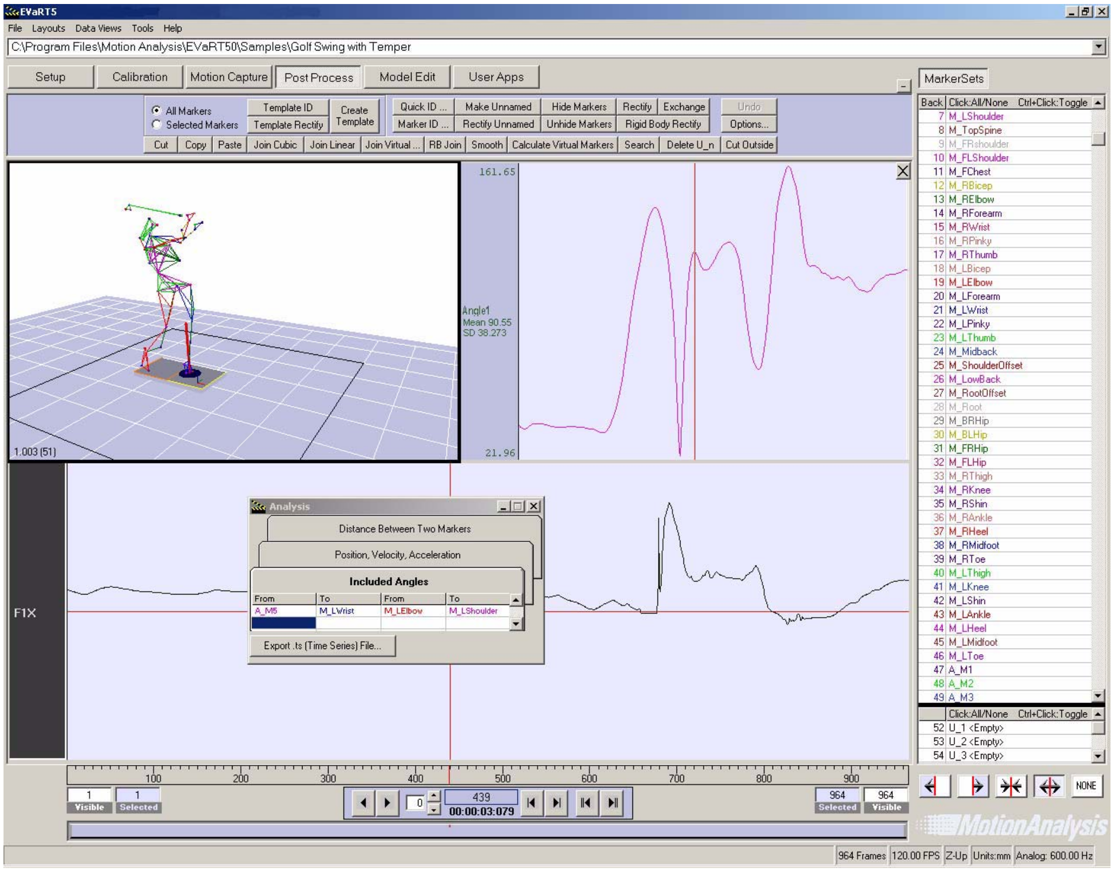

EVaRT5
File Layouts Data Views Tools Help
C:\Program Files\Motion Analysis\EVaRT50\Samples\Golf Swing with Temper
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
MarkerSets
Distance1
Mean 579.71
SD 67.405
Distance2
Mean 361.59
SD 28.927
F1X
Analysis
Position, Velocity, Acceleration
Included Angles
Distance Between Two Markers
Export .ts (Time Series) File...
964 Frames
120.00 FPS
Z-Up
Units:mm
Analog: 600.00 Hz

First Marker	Second Marker
M_ShoulderOffs	M_LWrist
M_LElbow	M_LPinky

Included Angles Tab

The Included Angles tab allows you to select groups of four markers, which define two separate lines in space. Between these two lines, the angle is calculated for each frame through the tracked data. This information proves useful for detecting irregularities in movement, such as between two parts of a body. To delete a row, simply click on that row and press **Delete**. You may select and delete several rows at once by pressing **shift + click** on the rows and pressing **Delete**.

Figure 10-23. Included Angles Tab


EVaRT5
File Layouts Data Views Tools Help
C:\Program Files\Motion Analysis\EVaRT50\Samples\Golf Swing with Temper
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
MarkerSets
All Markers
Selected Markers
Template ID
Template Rectify
Create Template
Quick ID ...
Marker ID ...
Make Unnamed
Rectify Unnamed
Hide Markers
Unhide Markers
Rectify
Rigid Body Rectify
Exchange
Undo
Options...
Cut
Copy
Paste
Join Cubic
Join Linear
Join Virtual ...
RB Join
Smooth
Calculate Virtual Markers
Search
Delete U_n
Cut Outside
161.65
Angle1
Mean 90.55
SD 38.273
21.96
1.003 (51)
F1X
Analysis
Distance Between Two Markers
Position, Velocity, Acceleration
Included Angles
Export .ts (Time Series) File...
100
200
300
400
500
600
700
800
900
1
Visible
1
Selected
0
439
00:00:03:079
964
Selected
964
Visible
NONE
MotionAnalysis
964 Frames
120.00 FPS
Z-Up
Units:mm
Analog: 600.00 Hz

From	To	From	To
A_M5	M_LWrist	M_LElbow	M_LShoulder

Back	Click:All/None Ctrl+Click:Toggle
7	M_LShoulder
8	M_TopSpine
9	M_FRshoulder
10	M_FLShoulder
11	M_FChest
12	M_RBicep
13	M_RElbow
14	M_RForearm
15	M_RWrist
16	M_RPinky
17	M_RThumb
18	M_LBicep
19	M_LElbow
20	M_LForearm
21	M_LWrist
22	M_LPinky
23	M_LThumb
24	M_Midback
25	M_ShoulderOffset
26	M_LowBack
27	M_RootOffset
28	M_Root
29	M_BRHip
30	M_BLHip
31	M_FRHip
32	M_FLHip
33	M_RThigh
34	M_RKnee
35	M_RShin
36	M_RAnkle
37	M_RHeel
38	M_RMidfoot
39	M_RToe
40	M_LThigh
41	M_LKnee
42	M_LShin
43	M_LAnkle
44	M_LHeel
45	M_LMidfoot
46	M_LToe
47	A_M1
48	A_M2
49	A_M3

	Click:All/None Ctrl+Click:Toggle
52	U_1 <Empty>
53	U_2 <Empty>
54	U_3 <Empty>

Exporting Analysis Information

To export an ASCII text viewable file, select the **Export.ts (Time Series) File...** button. This will write a file with the same file name as the tracked file you are working on. It will contain the information from all three Analysis tabs.

Post Processing Strategies and Tips

The steps necessary to clean up data will vary significantly from one user to another. These tips are guidelines that outline a general approach to successful editing sessions.

- It is best to start identifying from Frame 1 forward. Then, identify from the last frame backwards. This entails naming unnamed markers using the Marker ID and Quick ID tools.
- Use of Rectify over small frame ranges may help in cleaning the data by taking unnamed data into named tracks.
- After identifying, the Post Process tools can be used to fill gaps and cut out unwanted data sections, fix abnormalities, and smooth anomalies, and can be used to exchange switched markers.

Note: It is recommended to save your files often, especially when performing heavy edits.

- Many users will select all markers and all frames and execute a Join Linear or Join Cubic, and possibly a Smooth as a very last editing step.
- Learning and using Hot Keys is critical to high productivity.

Chapter 11

Model Edit Panel

Topic	Page
Overview	11-1
Markers Sub-Panel	11-2
Tree View Sub-Panel	11-5
Virtual Markers	11-16
Virtual Marker Quick-Start Example	11-20

Overview

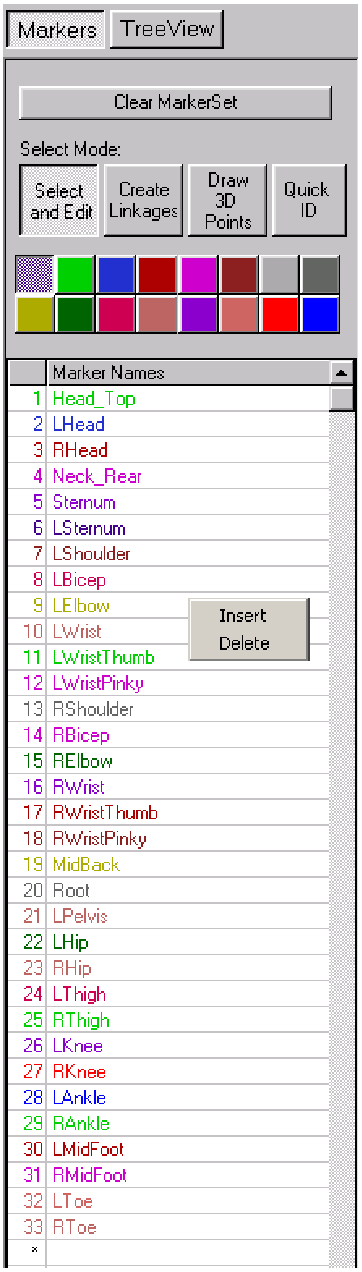
The Model Edit panel provides tools to build and modify the model parameters that are mandatory for the project file. These parameters include markers, virtual markers, linkages, and segments.

Note: It is important to save your project after building the model by selecting **File > Save Project**. For more information about project files (***.prj**), refer to “PRJ—EVaRT Project File” on page G-4.

Markers Sub-Panel

The Markers sub-panel is intended for building and modifying marker sets.

Figure 11-1. Markers Sub-Panel


Markers
TreeView
Clear MarkerSet
Select Mode:
Select and Edit
Create Linkages
Draw 3D Points
Quick ID
Insert
Delete

	Marker Names
1	Head_Top
2	LHead
3	RHead
4	Neck_Rear
5	Sternum
6	LSternum
7	LShoulder
8	LBicep
9	LElbow
10	LWrist
11	LWristThumb
12	LWristPinky
13	RShoulder
14	RBicep
15	RElbow
16	RWrist
17	RWristThumb
18	RWristPinky
19	MidBack
20	Root
21	LPelvis
22	LHip
23	RHip
24	LThigh
25	RThigh
26	LKnee
27	RKnee
28	LAnkle
29	RAnkle
30	LMidFoot
31	RMidFoot
32	LToe
33	RToe
*	

Clear Marker Set Button

This button clears out the project's marker set.

Create Markers This is done by double-clicking in the first box or by right-clicking and choosing **Insert**.

Select and Edit Button This allows you to select the names and colors of the markers in the marker set.

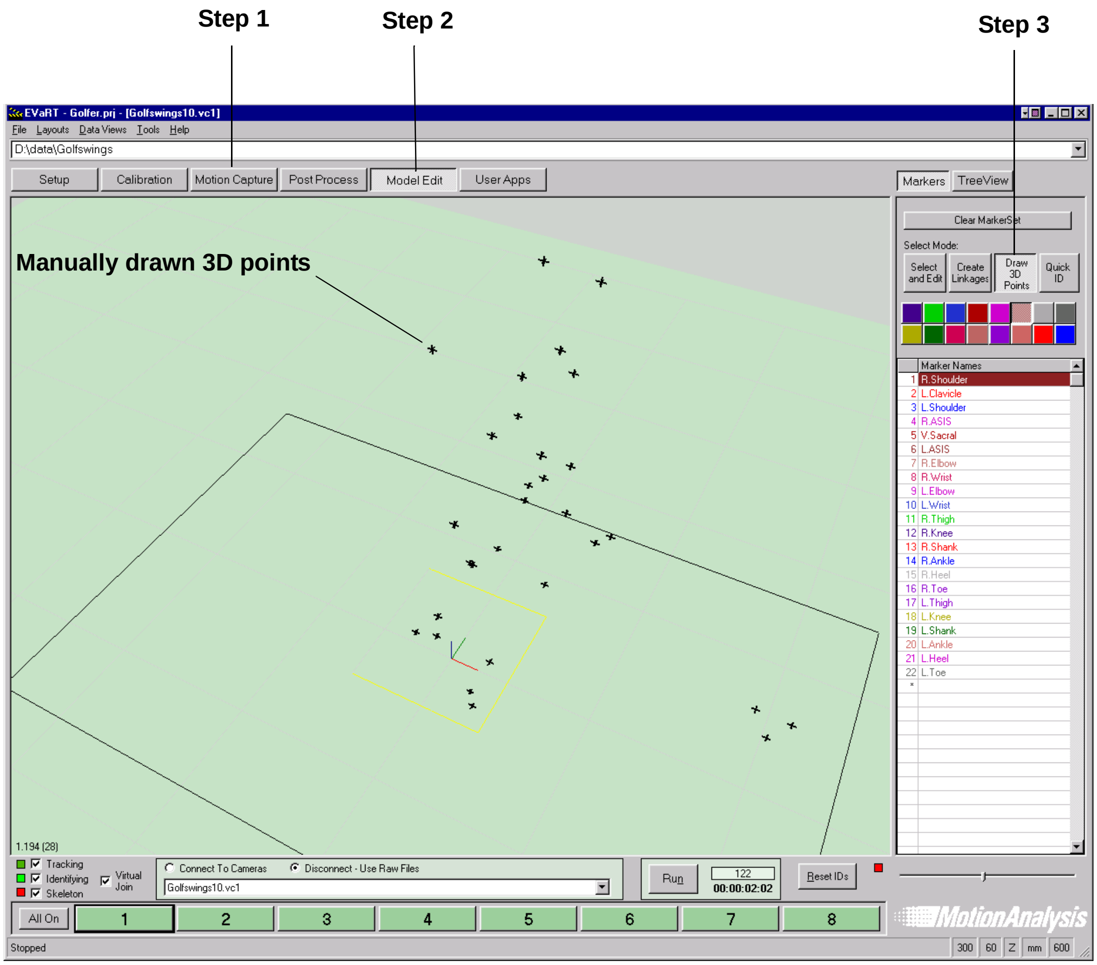
Create Linkages Button This button must be clicked prior to creating linkages on the 3D display. Linkages can be built by connecting the dots. Linkages should reflect the rigid segments.

Draw 3D Points Button This allows you to draw points manually onto the 3D display.

Note: You must be in Motion Capture before going into Model Edit to select **Draw 3D Points**.

Figure 11-2. Draw 3D Points

First select Motion Capture before going into Model Edit to select Draw 3D Points.

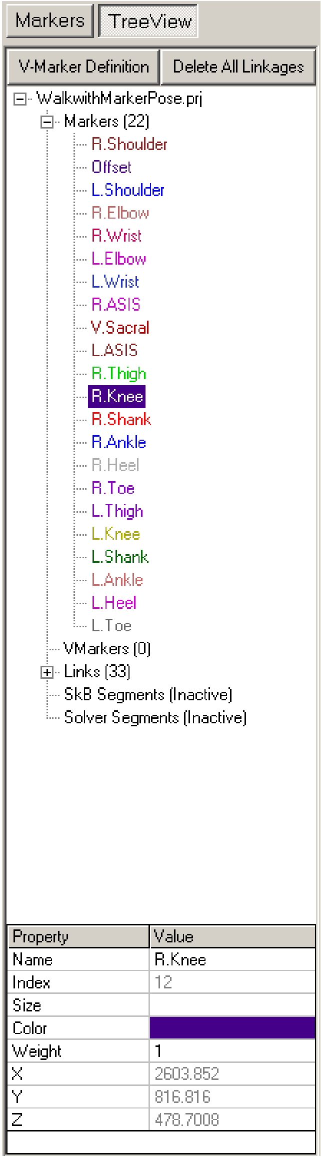

Step 1
Step 2
Step 3
EVaRT - Golfer.prj - [Golfswings10.vc1]
File Layouts Data Views Tools Help
D:\data\Golfswings
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Markers
TreeView
Clear MarkerSet
Select Mode:
Select and Edit
Create Linkages
Draw 3D Points
Quick ID
Manually drawn 3D points
Marker Names
1 R.Shoulder
2 L.Clavicle
3 L.Shoulder
4 R.ASIS
5 V.Sacral
6 L.ASIS
7 R.Elbow
8 R.Wrist
9 L.Elbow
10 L.Wrist
11 R.Thigh
12 R.Knee
13 R.Shank
14 R.Ankle
15 R.Heel
16 R.Toe
17 L.Thigh
18 L.Knee
19 L.Shank
20 L.Ankle
21 L.Heel
22 L.Toe
1.194 (28)
☑ Tracking
☑ Identifying
☑ Skeleton
☑ Virtual Join
○ Connect To Cameras
● Disconnect - Use Raw Files
Golfswings10.vc1
Run
122
00:00:02:02
Reset IDs
All On
1
2
3
4
5
6
7
8
MotionAnalysis
Stopped
300
60
Z
mm
600

Quick ID Button	This identifies the selected marker and steps through the listed markers one-by-one. It will normally select with auto incrementation (Auto Increment).
Marker Names	Marker names are accepted in the markers grid when you press **Enter** on the keyboard.
Delete Key	The Delete key will delete the current selected item from the marker set.

Tree View Sub-Panel

The Tree View sub-panel provides an overview of the primary elements of the model and allows you to reorder the markers in the marker set by dragging and dropping. You can also insert and delete markers as well.

Figure 11-3. Tree View Sub-Panel


Markers
TreeView
V-Marker Definition
Delete All Linkages
WalkwithMarkerPose.prj
Markers (22)
R.Shoulder
Offset
L.Shoulder
R.Elbow
R.Wrist
L.Elbow
L.Wrist
R.ASIS
V.Sacral
L.ASIS
R.Thigh
R.Knee
R.Shank
R.Ankle
R.Heel
R.Toe
L.Thigh
L.Knee
L.Shank
L.Ankle
L.Heel
L.Toe
VMarkers (0)
Links (33)
SkB Segments (Inactive)
Solver Segments (Inactive)

Property	Value
Name	R.Knee
Index	12
Size	
Color	🟪
Weight	1
X	2603.852
Y	816.816
Z	478.7008

V-Marker Definition Button

This button opens the Virtual Marker Definition form. For more information, refer to Virtual Markers on the following page.

Delete All Linkages Button

This deletes all linkages in the model.

Project

Selecting the Project in the Treeview allows you to make changes to the current project file. The Project property values that can be changed include the following:

Name

This is the marker set name you can display over the marker cloud. The toggle function for this is found 3D Display right-click menu. The default is set to the current project name.

Skeleton Engine

This provides a way to select which skeleton engine will be used to create the bone structure (if used). The choices are:

- None
- Skeleton Builder (SkB)
- Calcium Type Skeleton—Note that this can have an optional MOD file associated to it.
- SIMM OrthoTrak Skeleton—Note that this requires an associated JNT file and an Init or T-pose trial.

Skin File

Skin files are rigid shells that do not scale with different sized subjects, and do not span/stretch across joints. See Talon Viewer for these capabilities.

The Skin File function allows you to select one of four pre-defined skins that work with **EVaRT**. These skins that are defined for two different skeleton types and are located in the **C:\Program Files\Motion Analysis\EVaRT50\User Files\Skins** directory. The four skin types are:

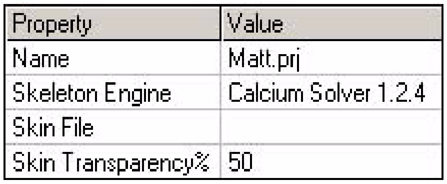
1. OrthoTrak Male (**MaleOTSkin.obj**)
2. OrthoTrak Female (**FemaleOTSkin.obj**)
3. OrthoTrak Polygons (**PolyBonesOT_Skin.obj**)
4. 25 Bone Animation Skin (**25_Bones_Male.obj**)

If you are looking to develop an entirely new skin file, you will need to contact Motion Analysis Customer Support (support@motionanalysis.com) for information.

Skin Transparency

This sets the transparency attribute of the skin—100% means the skin is invisible, 0% is solid.

Figure 11-4. Project Property Values



Property	Value
Name	Matt.prj
Skeleton Engine	Calcium Solver 1.2.4
Skin File	
Skin Transparency%	50

ShowIng the Skin

An OBJ skin consists of two files:

1. A skin file: **<Skin>.obj**
2. An associated base position: **<Skin>_Base.htr**

The HTR and OBJ file must have "group" names that match the base position HTR’s segment names. The base position HTR file must have segment names that match the marker set. The order of the names doesn't matter. The matching is done with the currently selected skeleton engine.

To select it:

1. Go to **Model Edit >TreeView**.
2. Select the project name (first line of the tree).
3. Select the Skin File property (at the bottom of the sup-panel).
4. Select a file in the Open File dialog.

The filename is saved in the project file, so each marker set can include a skin.

Note: The skin file and the associated HTR file is not saved in the project file. Only their names and relative directory paths are saved.

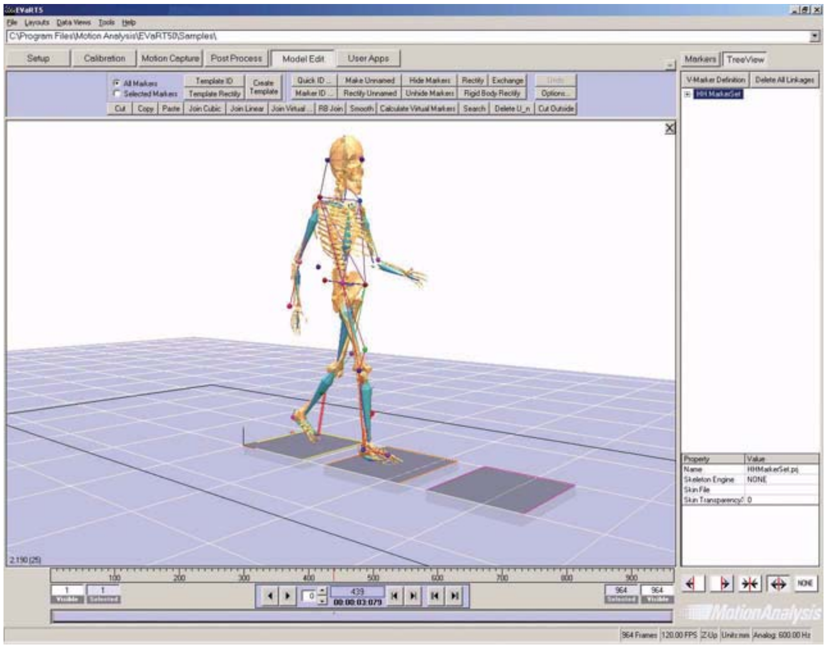
OrthoTrak Example

The following is an example of how to get the OrthoTrak skins to show in the 3D display.

1. Select **File > Load Project...** and load the project file **Walk.prj** located in the **Samples\Helen Hayes Markers** directory.
2. Select **File > Load Tracks...** and load **Walk1.trb**.
3. Click on the **Bone Button** in the lower-left of the **EVaRT** interface.
4. Go to the Model Edit panel and select the project in the Treeview.
5. Select the Skin File in Property Value and select **PolyBonesOT_Skin.obj.**
6. Right-click in the 3D display and select **Show Skins** and **Show Skeleton**.

This procedure will produce a subject with a skeleton and skin as shown in Figure 11-5.

Figure 11-5. OrthoTrak Skeleton and Skin Subject


EVaRT5
File Layouts Data Views Tools Help
C:\Program Files\Motion Analysis\EVaRT50\Samples\
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Markers
TreeView
HH MarkerSet
MotionAnalysis

Property	Value
Name	HHMarkerSet.prj
Skeleton Engine	NONE
Skin File	
Skin Transparency(0	0

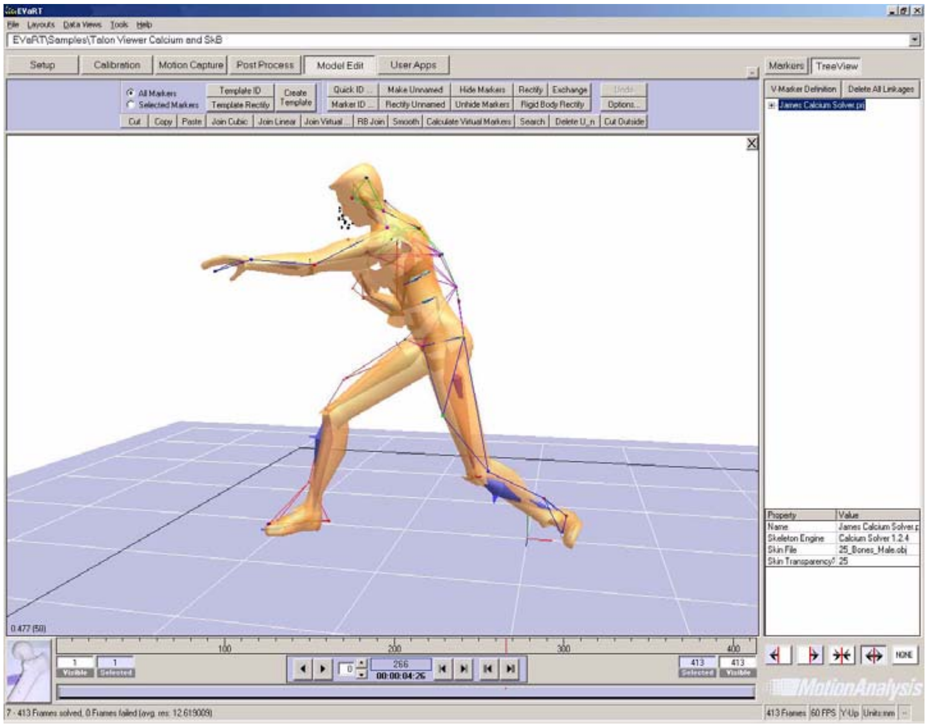
Animation Example

The following is an example of how to get the 25 Bone skin to show in the 3D display.

1. Select **File > Load Project...** and load the project file **Calcium Solver.prj** located in the **Samples\Talon Viewer Calcium and SkB** directory.
2. Select **File > Load Tracks...** and load **DaveUmpOut.trb**.
3. Click on the **Bone Button** in the lower-left of the **EVaRT** interface.
4. Go to the Model Edit panel and select the project in the Treeview.
5. Click on the Skin File in Property Value and select **25_Bones_Male.obj.**
6. Right-click in the 3D display and select **Show Skins** and **Show Skeleton**.

This procedure will produce a subject with a skeleton and skin as shown in Figure 11-6.

Figure 11-6. Animation Skeleton and Skin Subject


EVaRT
File Layouts Data Views Tools Help
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Markers
TreeView
◉ All Markers
○ Selected Markers
Template ID
Template Rectify
Create Template
Quick ID ...
Marker ID ...
Make Unnamed
Rectify Unnamed
Hide Markers
Unhide Markers
Rectify
Exchange
Rigid Body Rectify
Undo
Options...
Cut
Copy
Paste
Join Cubic
Join Linear
Join Virtual ...
RB Join
Smooth
Calculate Virtual Markers
Search
Delete U_n
Cut Outside
V-Marker Definition
Delete All Linkages
James Calcium Solver.prj
0.477 (58)
100
200
300
400
Visible
Selected
266
00:00:04:26
MotionAnalysis
NONE

EVaRT\Samples\Talon Viewer Calcium and SkB

Property	Value
Name	James Calcium Solver.p
Skeleton Engine	Calcium Solver 1.2.4
Skin File	25_Bones_Male.obj
Skin Transparency?	25

7 - 413 Frames solved, 0 Frames failed (avg. res: 12.619009)

413 Frames | 60 FPS | Y-Up | Units:mm

Markers

Selecting Markers in the Treeview allows you to make changes to any of the markers associated with the current project file using the property value selections at the bottom of the sub-panel. You can also insert, delete and select a range of markers.The marker values that can be changed include the following:

Name

Displays and edits the name of the selected marker.

Index

Displays the marker number, in the order the marker appears in the marker list. This is not editable.

Size

This is not used at this time.

Color

Displays and edits the color associated to the maker in the 3D display. To change the color, click on the color property and select from the drop-down menu.

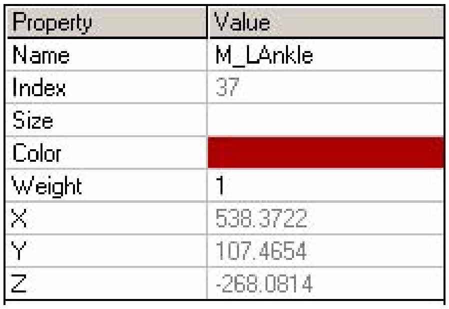
Weight

This is not used at this time.

X, Y, and Z Values

The 3D coordinates of the marker in calibration units at the frame number where the marker is selected. It is not updated with every frame change, but is updated when you select the marker.

Figure 11-7. Marker Property Values



Property	Value
Name	M_LAnkle
Index	37
Size	
Color	🟥
Weight	1
X	538.3722
Y	107.4654
Z	-268.0814

VMarkers

Selecting VMarkers in the Treeview allows you to make changes to the virtual markers in the current project file. The VMarkers property values that can be changed include the following:

Name

Displays and edits the name of the selected VMarker.

Index

Displays the VMarker number, in the order it appears in the list of VMarkers for the project. This is not editable.

Type

This provides a way to select which type of virtual marker to be created:

1. Two-Point (Ratio)
2. Two-Point (Value)
3. Three-Point (Ratio)
4. Three-Point (Value)

Origin Marker

Allows you to select and edit which marker is the Origin Marker of the Virtual Marker definition. To edit, click on the property and select from the drop-down menu.

Long Axis (Y)

Allows you to select and edit which marker is the Long Axis (Y) of the Virtual Marker definition. To edit, click on the property and select from the drop-down menu.

Plane Axis (XY)

Allows you to select and edit which marker is the Plane Axis (XY) of the Virtual Marker definition. To edit, click on the property and select from the drop-down menu.

X Offset

Sets the X coordinate of a VMarker definition.

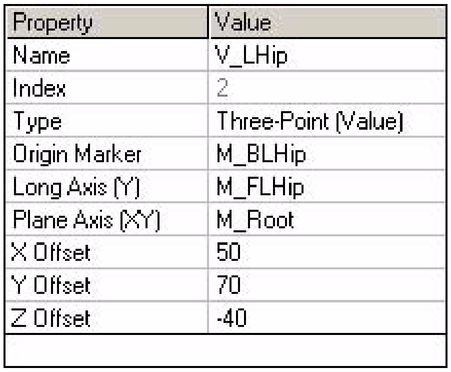
Y Offset

Sets the Y coordinate of a VMarker definition.

Z Offset

Sets the Z coordinate of a VMarker definition.

Figure 11-8. VMarker Property Values



Property	Value
Name	V_LHip
Index	2
Type	Three-Point (Value)
Origin Marker	M_BLHip
Long Axis (Y)	M_FLHip
Plane Axis (XY)	M_Root
X Offset	50
Y Offset	70
Z Offset	-40

Links

Selecting any of the links in the Treeview allows you to make changes to the links in the current project file. The link property values that can be changed include the following: Right-click can only delete.

Index

Displays the link number, in the order the link appears in the list of links for the project. This is not editable.

Marker1

Allows you to select and edit which marker is the first end point of the link definition. To edit, click on the property and select from the drop-down menu.

Marker2

Allows you to select and edit which marker is the 2nd (of two) end point of the link definition. To edit, click on the property and select from the drop-down menu.

Color

Displays and edits the color associated to the link in the 3D display. To change the color, click on the color property and select from the drop-down menu.

Extra Stretch

The Extra Stretch factor is a statement about the quality of the motion that was used to create the template values. The Extra Stretch is a "Confidence Factor" in the data used to make the template. What confuses the user most is that rigid body parts (the head is a good example) will not have their markers move around much no matter what data you use to create the template. So almost any template will work to give you values with high confidence. Conversely, if you have links that are stretchy, it's easy to not get a good template for it and so your confidence in the template will be less.

Because of this, many users think that the Extra Stretch factor is a statement about the stretchiness of the link, which it isn't. A link could be put between a hand marker and the toe marker but as long as it had sufficient data for the template Extra Stretch could be set to 1 (the lowest) and have it work just fine.

This is why there is a **CreateTemplate.sky** script. It shows how to use multiple TRB files as input to the template creation (and extension) process.

Assuming a standard Range of Motion (ROM) file, the Extra Stretch values are normally set as follows:

- 10 for the head
- 15 for the links on the hips/pelvis
- 15 for the feet
- 20 everywhere else

This is a starting point. As data is tracked, you can fine-tune the Extra Stretch values.

In order to maintain compliance with legacy datasets, the Extra Stretch factor is not used in the same way in the Motion Capture panel as it is in Post Process. In Post Process, the Extra Stretch is used in all operations that use the template (TemplateID and Template Rectify). In Motion Capture, when processing data live from the cameras or from VC files, the

Extra Stretch is used as part of the TemplateID but not as part of the Template Rectify. For the rectifying process the Linkage Stretch parameters are still used to specify how to treat the data in the main marker set.

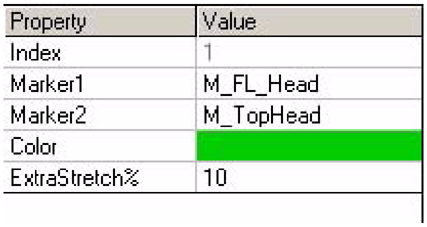
However, all additional tracking objects in slots A, B, C, etc... use the Extra Stretch factor for all Template operations (just like in Post Process). Only the main marker set is treated differently. The reason for the difference is the way in which the template has been used in the past during live capture (and still is for the main marker set). The template definition is used as a starting point for the rectifying process. The TemplateID identifies the markers using the Extra Stretch factor and then the template is modified on a frame by frame basis called the "running template". The running template is essentially the original template with an extend template operation performed on the template for each frame. This is why the "Reset ID" button doesn't always work - if bad (swapped) data gets into the template then that information is encoded into the template. The only way to completely reset the running template is to Pause and then Run.

The running template continues to be modified for as long as the system is running without pause. Without any kind of check on this process the template could get extremely different than the original template. The Linkage Stretch parameters put a brake on the process. They specify how different the running template is allowed to be. In future versions of **EVaRT** the Linkage Stretch parameters in the Tracking Parameters interface will become obsolete when the main marker set uses the Extra Stretch factor just like it is used everywhere else. By then it is expected that users will have modified their marker sets to take advantage of the Extra Stretch factor and so the transition to the new technique will be seamless.

General Notes on Extra Stretch

- Extending the template works exactly as if you took all the TRB data used to create the template and put it end to end and did a Create Template with the whole works at once.
- If the ES factors are too large you get misidentified markers.
- If the ES factors are too small (and your template isn't complete enough) you will get unidentified markers.
- The template is a pair of Min/Max values for each link. These values only get farther apart as you extend the template. If they are too far apart (as might happen if you had bad data to create the template) then you must start the template creation process over from the beginning because there's no way to tell the numbers to get close together (again, this is why I made a Sky script for this - it makes it trivial to redo the template creation process).

Figure 11-9. Link Property Values



Property	Value
Index	1
Marker1	M_FL_Head
Marker2	M_TopHead
Color	🟩
ExtraStretch%	10

SkB Segments

Name

Displays and edits the name of the selected SkB segment.

Index

Displays the SkB segment number, in the order the segment appears in the list for the project. This is not editable.

Parent

Displays the parent segment of the selected SkB segment. To edit, click on the property and select from the drop-down menu.

Origin Marker

Allows you to select and edit which marker is the Origin Marker of the SkB segment definition. To edit, click on the property and select from the drop-down menu.

Long Axis (Y)

Allows you to select and edit which marker is the Long Axis (Y) of the SkB segment definition. To edit, click on the property and select from the drop-down menu.

Plane Axis (XY)

Allows you to select and edit which marker is the Plane Axis (XY) of the SkB segment definition. To edit, click on the property and select from the drop-down menu.

RX Offset

RX is used to rotate the bone in the SkB segment along the X axis. RX is not used very often compared to RY. If you select a segment to rotate, it will bring up the rotation gizmo.

RY Offset

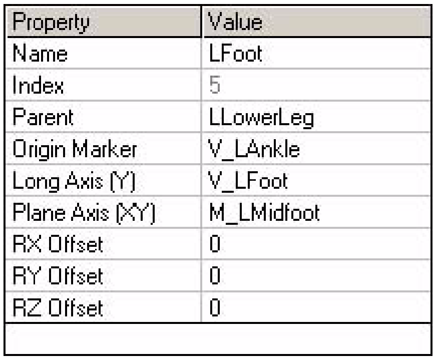
RY is used to rotate the bone along the Y axis. If you select a segment to rotate, it will bring up the rotation gizmo.

RZ Offset

RZ is used to rotate the bone in the SkB segment along the Z axis. RZ is not used very often compared to RY. If you select a segment to rotate, it will bring up the rotation gizmo.

For more information on Skeleton Builder, refer to the Skeleton Builder Quick-Start Guide found in the **C:\Program Files\Motion Analysis\EVaRT50\Samples\Skeleton Builder** directory.

Figure 11-10. Skeleton Builder Segments Property Values



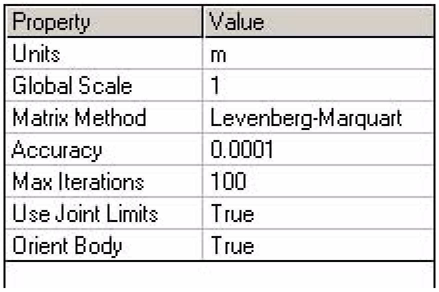
Property	Value
Name	LFoot
Index	5
Parent	LLowerLeg
Origin Marker	V_LAnkle
Long Axis (Y)	V_LFoot
Plane Axis (XY)	M_LMidfoot
RX Offset	0
RY Offset	0
RZ Offset	0

The various skeleton types are described in Chapter 13, Skeleton Types.

Calcium Segments

Calcium is the graphical user interface to the Solver engine. Solver is the powerful numerical tool for calculating skeleton motion from marker data. The Calcium interface in **EVaRT** is what allows you to correlate the positions of a marker pose to the initial pose of a skeleton. The skeleton is usually created in an outside animation package, such as Maya, 3D Studio Max or Kaydara and then exported to an HTR file by a Motion Analysis file IO plugin for that package. In this example we're using a skeleton from a Maya character.

Figure 11-11. Calcium Segments Property Values



Property	Value
Units	m
Global Scale	1
Matrix Method	Levenberg-Marquart
Accuracy	0.0001
Max Iterations	100
Use Joint Limits	True
Orient Body	True

Units

Units of the Calcium segment lengths. Select from the drop-down menu in meters, centimeters, and millimeters.

Global Scale

Changes the scale of the entire hierarchy, multiplied by the number set (e.g. a value of 10 would scale the hierarchy by 10 times the original size). This provides a quick method for scaling the HTR file to fit the marker cloud in the model pose.

Matrix Method

There are two matrix methods to choose from:

- **Gauss Newton**—Which is faster at solving, but not as robust. This is generally used in Real Time applications.

- **Levenberg-Marquart**—While is more robust, but not as fast. This should only be used in PP mode.

Accuracy

This is the accuracy parameter for the solve. It is generally set to .0001 and then left alone. It can be useful to debug and troubleshoot the Calcium segment.

Max Iterations

This is the number of iterations the solver goes through to solve. When the solver gets "stuck", it can potentially iterate forever. Usually the solve happens in a very small number of iterations (1-5). Setting it to 100 is more than enough.

Use Joint Limits

Enables or disables the use of joint limits in the Calcium model. Generally it is recommended to be turned off for animation applications. If the solution has joints flipping around, turn it off. Any model created from a joint file should have the limits enabled.

Orient Body

This is important on the first frame of any solve. First orient the root bone to the root bone markers, then do the solve. This helps to eliminate some first frame errors when bones get oriented incorrectly.

Note: There is still a bug where joints get turned around on the first frame. The solve changes randomly whenever these last two flags are changed. User beware.

It is recommended that Orient Body is set to False when Real Time operation performance is a factor.

For complete information on Calcium software and Calcium segment definitions, please reference the *Calcium for EVaRT Quick-Start Guide* (p/n 651-1920-010).

Virtual Markers

Virtual markers are markers that get their position from a combination of the position of two or three actual markers in the motion capture data. Typically, a virtual marker is used to generate the actual joint center position of the performer (or subject) being motion captured. This is necessary since the actual markers lie on the outside of the performer. Joint center markers are desirable for use with analytical and skeleton reconstruction tools.

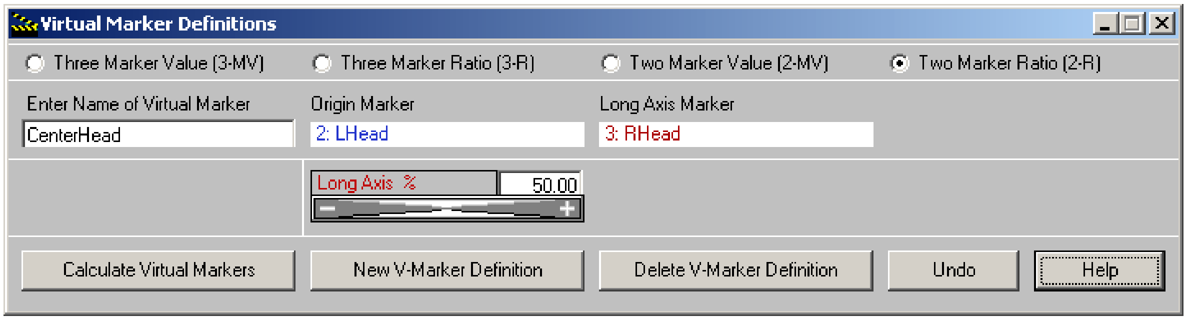
Virtual Marker Definitions

There are two methods for defining Virtual Markers (VM):

1. **2 Marker -** Two markers are used to define a line in space. A new virtual marker can be calculated anywhere on this line.
2. **3 Marker -** Three markers are used to define a plane in space. A new virtual marker can be calculated anywhere in space relative to the origin of this plane.

The placement of the virtual marker along a line or relative to a plane can be accomplished in real world measured values using the units of calibration as the units of measurement, or as a ratio. In the case of a line, the ratio is based on the distance between the two markers defining the line. In the case of the plane, the ratio is based on the distance between the two markers defining the Y axis of the plane.

Figure 11-12. Example Virtual Marker Setup


Virtual Marker Definitions
Calculate Virtual Markers
New V-Marker Definition
Delete V-Marker Definition
Undo
Help

○ Three Marker Value (3-MV) ○ Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ● Two Marker Ratio (2-R)

Enter Name of Virtual Marker: CenterHead

Origin Marker: 2: LHead

Long Axis Marker: 3: RHead

Long Axis %: 50.00

Types of Virtual Hierarchical Translation & Rotation Data

Currently, there are two primary methods of exporting the motion of a subject:

- ***.trc** (track row column) output files
- ***.htr2** (hierarchical translational rotation) output files

A ***.trc** file contains the X, Y, and Z translation values for the reflective markers relative to the capture volume’s coordinate system. To translate this data into a hierarchical segment model requires software having an Inverse Kinematic (IK) Solver to create joint translations and rotations. This I.K. approach works well when the proportions of the subject are similar to the animation model.

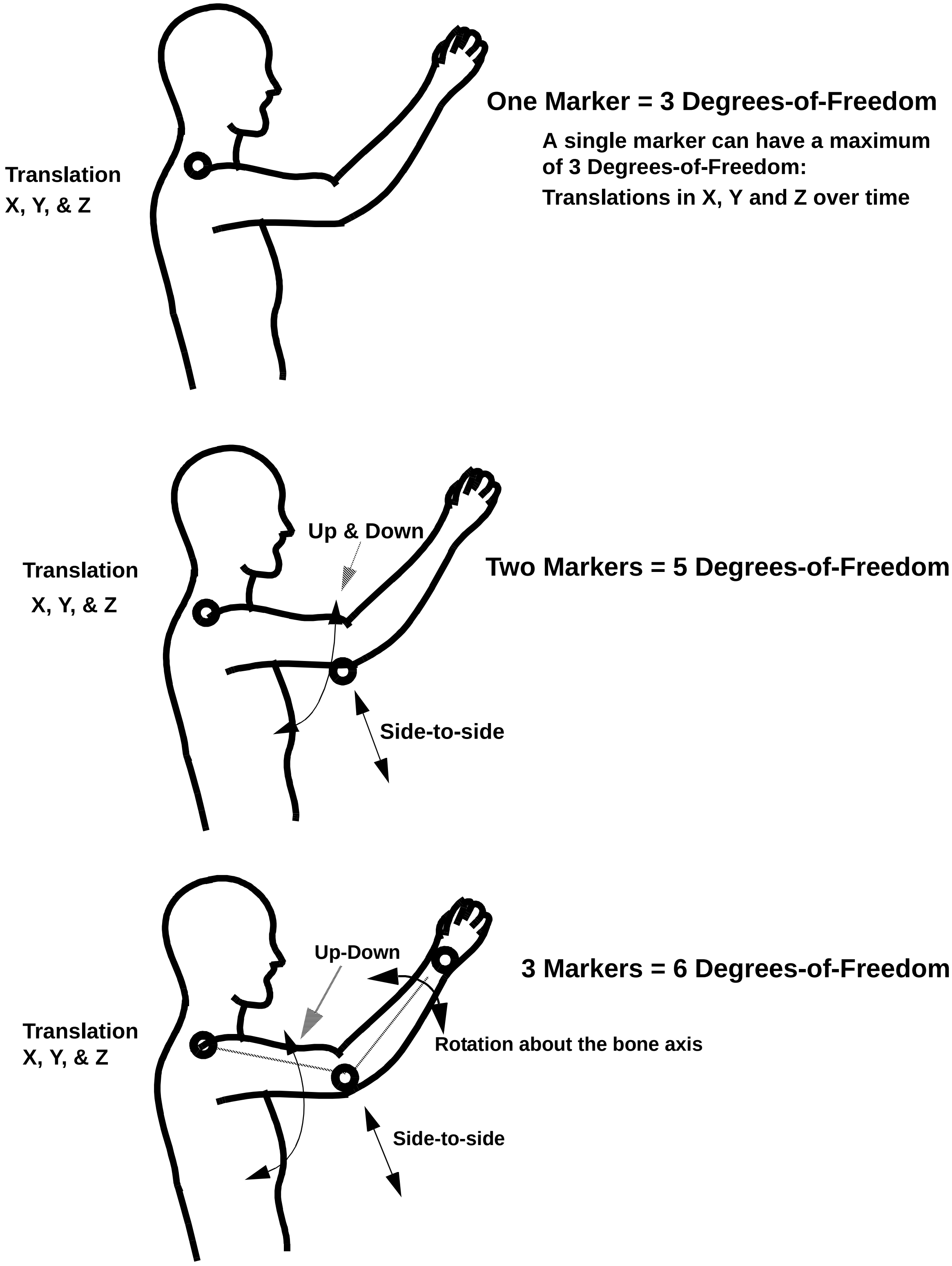
An ***.htr2** file contains hierarchical translation and rotation data representing the different identified segments (bones) of the subject’s body. In this approach, you must establish virtual markers at the estimated joint centers and create segment coordinate systems for each segment. The virtual markers and segment coordinate systems are defined once for a particular marker set and then stored and recalled from the project file.

Degrees of Freedom

A segment’s movement characteristics can be expressed as having various degrees-of-freedom. For example, if a single marker placed on the right shoulder is used to define the origin of the right upper arm, and we track this marker through space creating a trajectory, we will express the movement of the right upper arm origin as having 3 degrees-of-freedom (translations in X,Y, and Z).

If we add another marker to the right elbow and track it along with the marker on the right shoulder, we can now express movement of the right upper arm segment as having 5 degrees-of-freedom (translations in X, Y, and Z, and rotations in X and Z). This assumes that the Y axis extends from the right shoulder to the right elbow. If we add a third marker to the right wrist and track all three markers, we now have 6 degrees-of-freedom for the right upper arm segment.

Figure 11-13. Marker Number vs. Degrees of Freedom

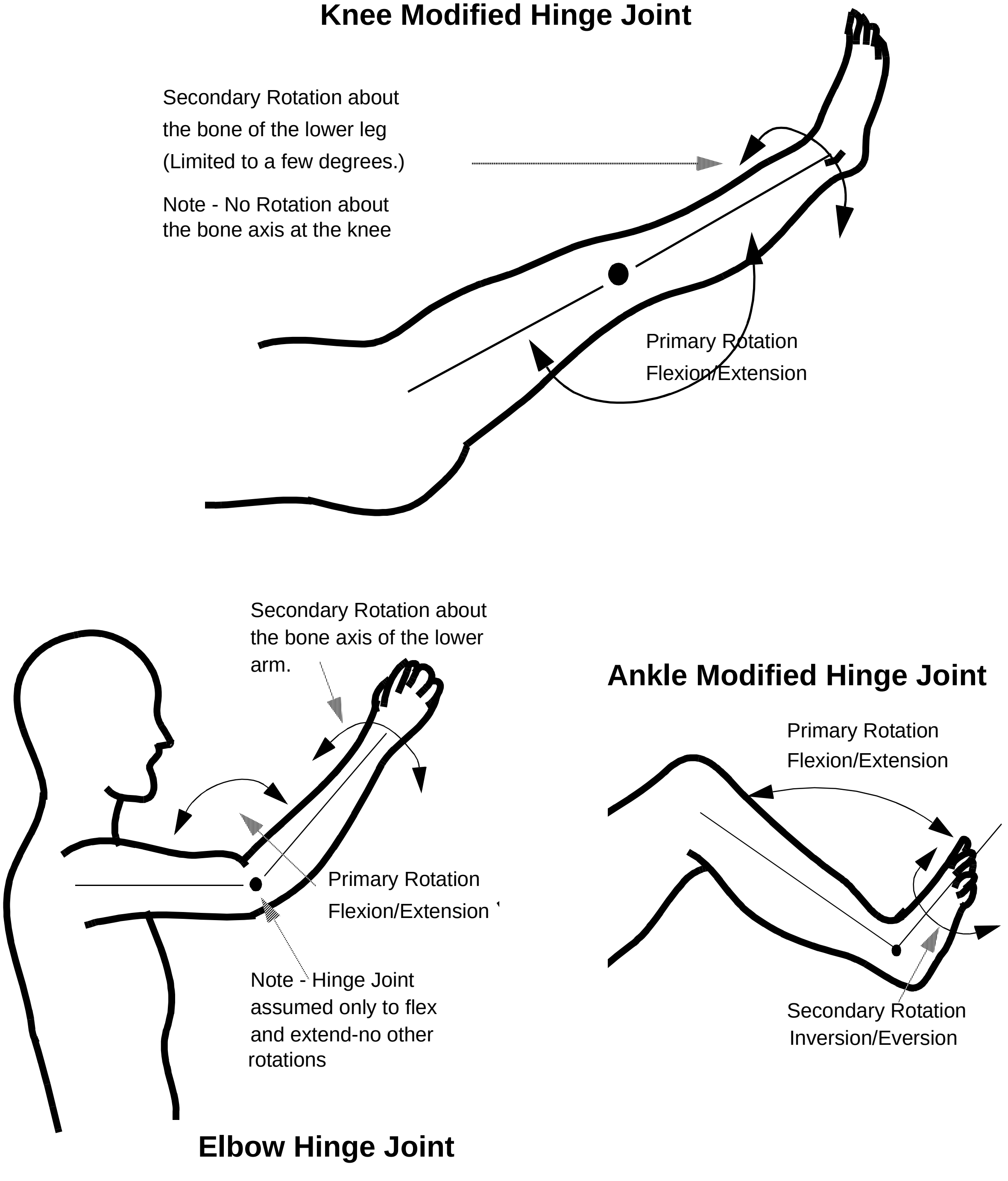


Translation
X, Y, & Z
One Marker = 3 Degrees-of-Freedom

A single marker can have a maximum of 3 Degrees-of-Freedom:
Translations in X, Y and Z over time

Translation
X, Y, & Z
Up & Down
Two Markers = 5 Degrees-of-Freedom
Side-to-side
Translation
X, Y, & Z
Up-Down
3 Markers = 6 Degrees-of-Freedom
Rotation about the bone axis
Side-to-side

Figure 11-14. Examples of Hinge Joints


Knee Modified Hinge Joint
Secondary Rotation about the bone of the lower leg (Limited to a few degrees.)
Note - No Rotation about the bone axis at the knee
Primary Rotation Flexion/Extension
Secondary Rotation about the bone axis of the lower arm.
Primary Rotation Flexion/Extension
Note - Hinge Joint assumed only to flex and extend-no other rotations
Elbow Hinge Joint
Ankle Modified Hinge Joint
Primary Rotation Flexion/Extension
Secondary Rotation Inversion/Eversion

Calculating Virtual Marker Tracks

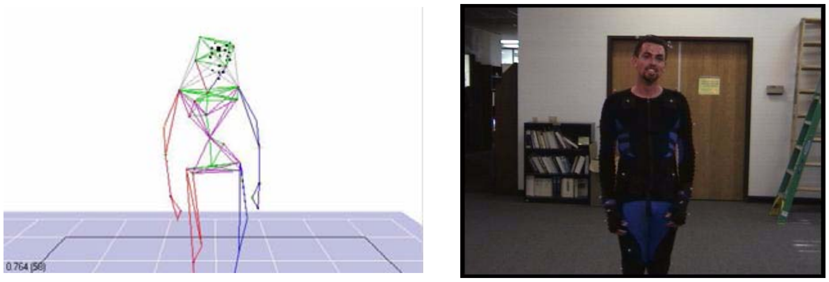
Calculate virtual marker trajectories based on the Virtual Marker definitions in the current project file. Virtual Markers are cleared when you track any new data.

Track and edit your trials before calculating the Virtual Marker Tracks.

1. Open the Virtual Markers Definitions form by clicking the **V-Marker Definitions** button in Model Edit or by selecting **Tools > Virtual Marker Definitions** in the Menu Bar.
2. Fill out the Virtual Marker Definitions form for the desired markers.
3. Click **Calculate** to calculate the virtual marker positions.

Virtual Marker Quick-Start Example

Figure 11-15. Matching Data and Video Frame



The above images show a frame of motion capture data along with a matching frame of video showing the posture of the performer. Of particular interest are the positions of the motion capture markers relative to his body. In this example, virtual marker definitions will be created that estimate the actual joint locations of the performer.

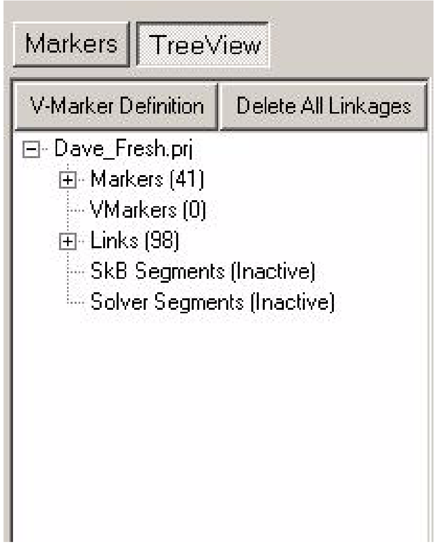
It is always a good idea, when adding virtual markers to a marker set, to differentiate the virtual markers from the standard markers by adding a prefix to the name. The choice is up to you, but common ones are "JC_" (for Joint Center), "VM_" or simply "V_". For this example, the last one will be chosen because, to help the user avoid name conflict problems, **EVaRT** inserts a "V_" at the beginning of the Name field of a new virtual marker definition.

Open the Sample Project

To follow along with the example, please get started by loading the sample data and opening the program to the correct panel:

1. Start **EVaRT** and load the project **Dave_Fresh.prj** located in the **EVaRT50/Samples/VirtualMarkers** directory.
2. Load the tracks file **Dave_ROM1.trb**.
3. Open the **Model Edit > TreeView** sub-panel. Figure 11-16 shows what you should see in the upper right of **EVaRT**

Figure 11-16. Initial Tree View for Dave_Fresh.prj



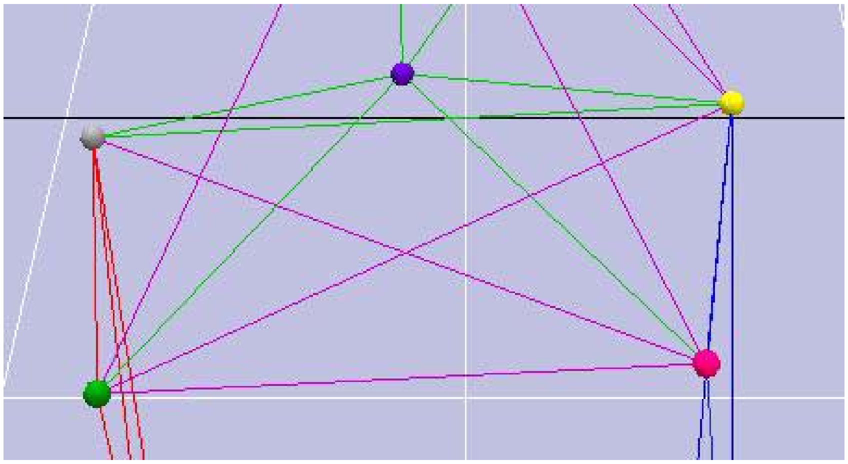
Dave_Fresh.prj
- Markers (41)
- VMarkers (0)
- Links (98)
- SkB Segments (Inactive)
- Solver Segments (Inactive)

Ensure that the Show Virtual Markers option is turned on by doing a right mouse click in the 3D display and viewing the Show menu.

Center of the Pelvis

It is common practice to use the pelvis area as the "root" of a skeleton structure representing a person's motion (the process of constructing such a hierarchy of bones will be described in detail in the Skeleton Builder Quick-Start Guide) it is normal to interleave the virtual marker creation process with the Skeleton Building process, therefore, as much as possible, the virtual marker definition process will match the Skeleton Building process even though these two guides are presented in two separate passes. Thus we start with the pelvis.

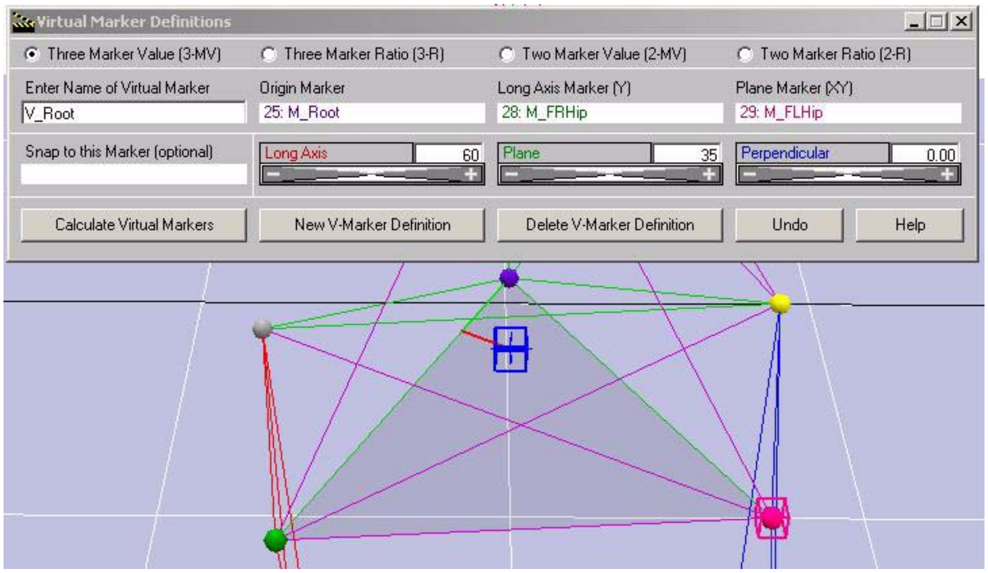
Figure 11-17. The Five Pelvis Markers



The above image shows a close-up of the 5 pelvis markers. Any combination of 3 of the markers could be used to create the virtual marker, but it is always a good idea to choose markers that are the farthest from co-linear as possible. In this case, the top marker (M_Root) and the two, front, lower markers (M_FLHip and M_FRHip) almost form an equilateral triangle, this is a nearly ideal configuration for numerical stability of the virtual marker calculation.

1. Start the marker definition by pressing the V-Marker Definition button.
2. The default setting of Three Marker Value (3-MV) is correct, do not change this.
3. Enter the name "V_Root" in the name field. When you press your keyboard Enter button the Origin Marker field will be highlighted.
4. With your mouse, do a single left mouse click on the M_Root marker in the 3D display. The highlighted field will switch to Long Axis Marker (Y).
5. With your mouse, do a single left mouse click on the M_FRHip marker in the 3D display. The highlighted field will switch to Plane Marker (XY).
6. With your mouse, do a single left mouse click on the M_FLHip marker in the 3D display. In the 3D display you will see a darkened triangle indicate the area of the virtual marker definition.
7. In the field Long Axis enter the value of 60.
8. In the field Plane enter the value of 35.
9. In the field Perpendicular, leave the value at 0.

Figure 11-18. Virtual Marker Definition for V_Root



Virtual Marker Definitions

● Three Marker Value (3-MV) ○ Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_Root

Origin Marker: 25: M_Root

Long Axis Marker (Y): 28: M_FRHip

Plane Marker (XY): 29: M_FLHip

Snap to this Marker (optional):

Long Axis: 60

Plane: 35

Perpendicular: 0.00

As you change the values in the numerical fields you will see the display of the virtual marker update. In this case, the option of Three Marker Value was chosen instead of Three Marker Ratio. The "Value" types of definitions interpret the numerical fields as millimeters. The "Ratio" types of definitions interpret the numerical fields as percentages. For the V_Root virtual marker, either three marker definition would be suitable. One advantage of the Three Marker Value definition is that it has the optional Snap to this Marker field. By highlighting this field and then selecting a marker, the values necessary for the virtual marker to be at the location of the selected marker will be entered into the numerical fields for you.

Play around with the values in the numerical fields to get a sense of how the virtual markers location is calculated and how EVaRT visually displays the calculation parameters to help you place the virtual marker.

There is no need to press Calculate Virtual Markers to see updates to definition changes. This button is for when you would like to see an XYZ graph of your virtual markers. There are times when this is helpful for reconstructing data when markers were lost (and it wasn't noticed) before the data was captured. The normal procedure is for EVaRT to automatically (re)calculate the virtual markers any time there are changes to the original data or to the marker definitions.

To create a new virtual maker definition press the button New V-Marker Definition, this will start you over with a fresh virtual marker definition.

To go back and edit previous virtual marker definitions you may do any one of these:

- Close the Virtual Marker Definition Window; select the virtual marker from the treeview and then press V-Marker Definition. -OR-

- Press the button New V-Marker Definition and then select an existing definition from the treeview. - OR-
- Select the virtual marker from the treeview and modify the parameters in the property editor in the lower right portion of the screen.

Each Leg

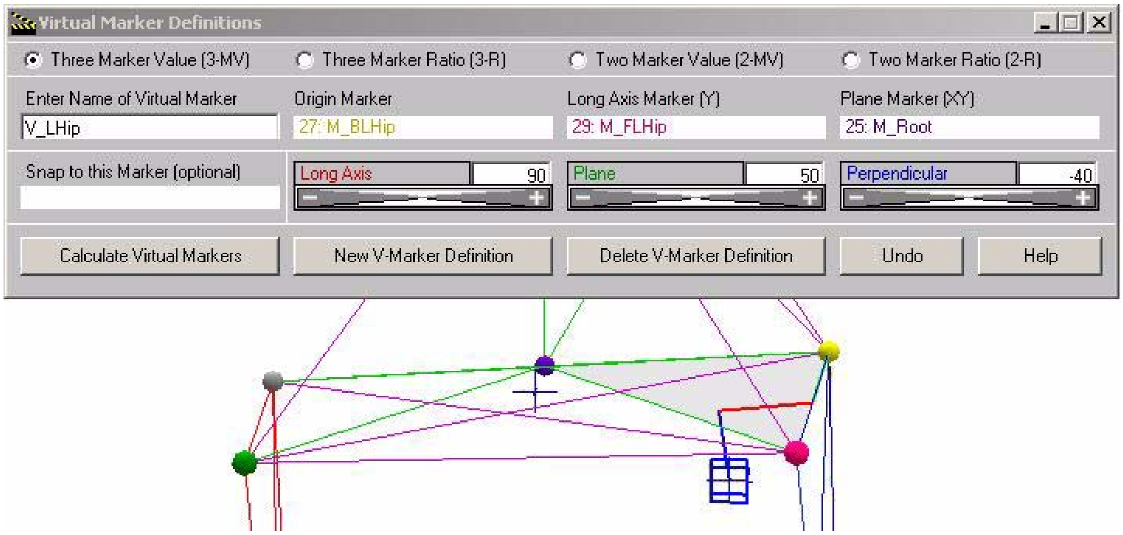
The process for creating virtual makers for each leg is symmetric so only the generation of the virtual markers for the left leg is shown here.

Hip

One of the goals of the virtual marker process is to create the markers as close to the person's actual joint centers as possible (in truth, there is no such thing as an actual joint center since real bones do not move in an idealized fashion - their joint center changes depending on the position of the bone - the knee joint's "center" may shift as much as 10 millimeters as the leg bends, for example). For the purposes of most applications, such as kinematic analysis and character animation, an approximation is good enough.

In the case of the hip joint, it is useful to note that the locations of the pelvis markers are usually above the actual location of the hip joint. So the position of the virtual marker with respect to the pelvis markers will be lowered as well as moved inwards.

Figure 11-19. Virtual Marker Definition for V_LHIp



Virtual Marker Definitions

● Three Marker Value (3-MV) ○ Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_LHip

Origin Marker: 27: M_BLHip

Long Axis Marker (Y): 29: M_FLHip

Plane Marker (XY): 25: M_Root

Snap to this Marker (optional):

Long Axis: 90

Plane: 50

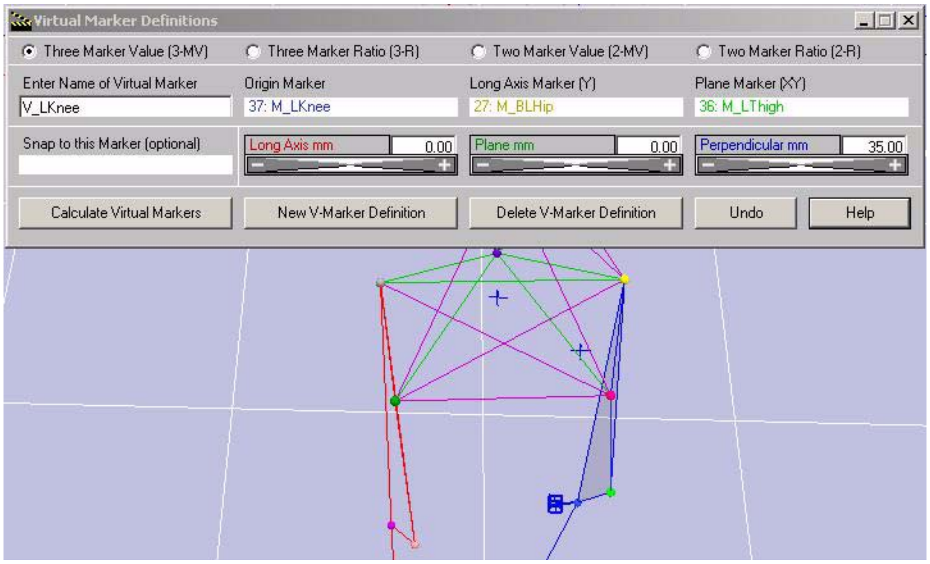
Perpendicular: -40

Like with the definition of the V_Root marker, the V_LHip definition uses the Three Marker Value type of definition. Note the use of the Perpendicular field to position the virtual marker lower than the 3 definition markers. This is possible because the Three Marker types of definitions create a fully 3D reference frame for positioning the virtual marker.

Knee

As with the definition of the V_LHip maker the goal for the definition of the V_LKnee marker is to estimate the location of the knee's joint center. In this case it is a matter of going straight in from the location of the knee marker on the outside of the knee.

Figure 11-20. Virtual Marker Definition for V_LKnee


Virtual Marker Definitions
Calculate Virtual Markers
New V-Marker Definition
Delete V-Marker Definition
Undo
Help

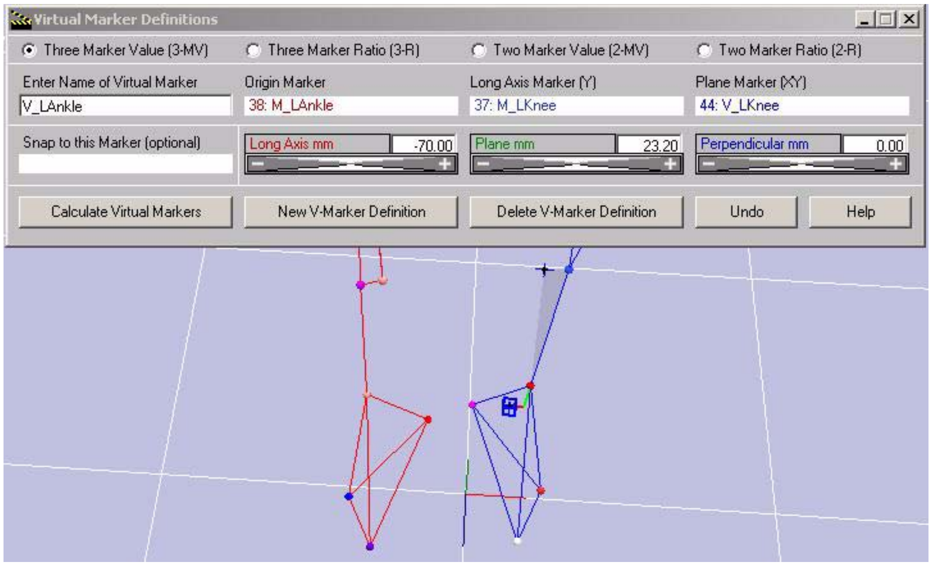
● Three Marker Value (3-MV) ○ Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_LKnee
Origin Marker: 37: M_LKnee
Long Axis Marker (Y): 27: M_BLHip
Plane Marker (XY): 36: M_LThigh
Snap to this Marker (optional):
Long Axis mm: 0.00
Plane mm: 0.00
Perpendicular mm: 35.00

Note: The yellow, M_BLHip marker is used instead of the red M_FLHip marker. The back hip marker is preferable because it is less co-linear than the front marker. This will help the V_LKnee calculations be more stable.

Ankle

Figure 11-21. Virtual Marker Definition for V_LAnkle



Virtual Marker Definitions
Calculate Virtual Markers
New V-Marker Definition
Delete V-Marker Definition
Undo
Help

● Three Marker Value (3-MV) ○ Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_LAnkle

Origin Marker: 38: M_LAnkle

Long Axis Marker (Y): 37: M_LKnee

Plane Marker (XY): 44: V_LKnee

Snap to this Marker (optional):

Long Axis mm: -70.00

Plane mm: 23.20

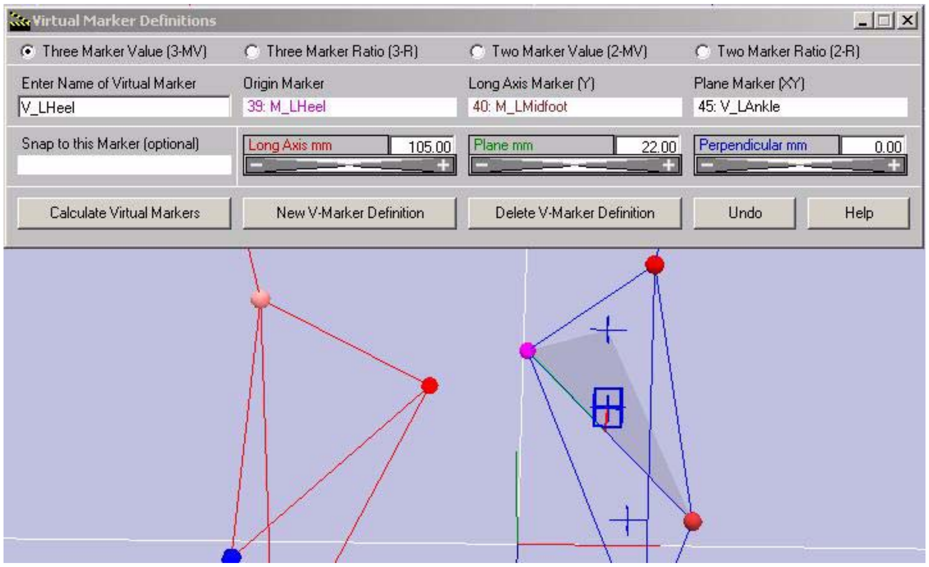
Perpendicular mm: 0.00

Notice that the definition of the V_LAnkle marker uses the previously defined virtual marker for the knee. It is perfectly acceptable to cascade virtual marker definitions in this fashion. For the V_LAnkle marker this is necessary since there are otherwise too few markers available to create an offset from the outside, original ankle marker. Also note the negative value in the Long Axis field, this lowers the virtual marker to a location that more closely represents the center of the ankle joint.

Heel

The heel virtual marker definition is optional, you may skip this definition and add just the V_LFoot marker. Like the V_LAnkle marker it relies on a previously defined virtual marker (the V_LAnkle marker, in fact) to generate its position. Once again, the Three Marker Value type is used:

Figure 11-22. Virtual Marker Definition for V_LHeel


Virtual Marker Definitions
Calculate Virtual Markers
New V-Marker Definition
Delete V-Marker Definition
Undo
Help

● Three Marker Value (3-MV) ○ Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_LHeel

Origin Marker: 39: M_LHeel

Long Axis Marker (Y): 40: M_LMidfoot

Plane Marker (XY): 45: V_LAnkle

Snap to this Marker (optional):

Long Axis mm 105.00

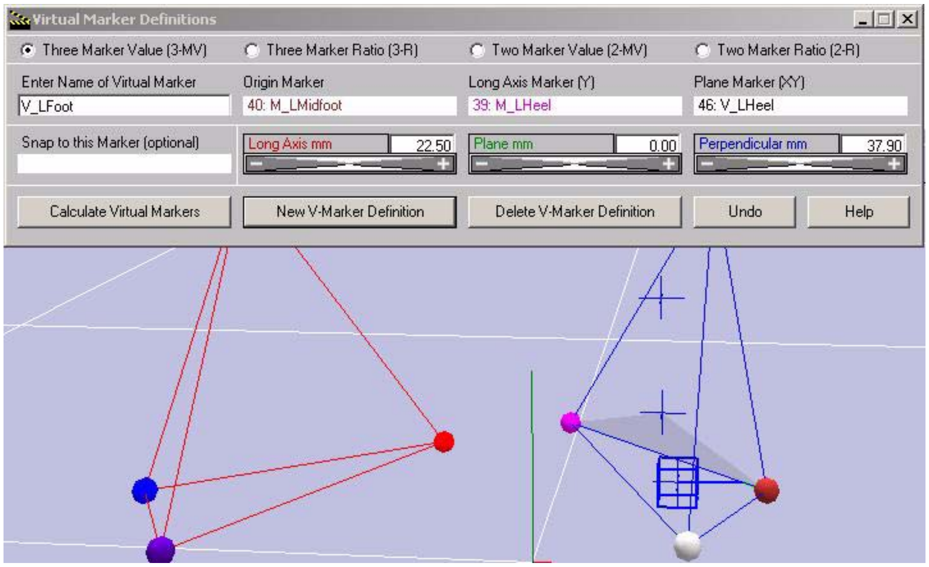
Plane mm 22.00

Perpendicular mm 0.00

Foot

The principal goal of the definition of all the markers for the foot area (ankle, heel and foot) was to align the markers in a plane that matches the V_LKnee and M_LToe markers. This will make for a more useful (as well as aesthetically pleasing) Skeleton Builder definition later.

Figure 11-23. Virtual Marker Definition for V_LFoot


Virtual Marker Definitions
Calculate Virtual Markers
New V-Marker Definition
Delete V-Marker Definition
Undo
Help

● Three Marker Value (3-MV) ○ Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_LFoot

Origin Marker: 40: M_LMidfoot

Long Axis Marker (Y): 39: M_LHeel

Plane Marker (XY): 46: V_LHeel

Snap to this Marker (optional):

Long Axis mm: 22.50

Plane mm: 0.00

Perpendicular mm: 37.90

Note that the V_LFoot marker uses nearly the same set of markers for its calculation as the V_LHeel. The order of the markers is different (different Origin Marker specification).

The virtual marker definitions for the right leg are done just like as shown for the left. The sample project **Dave_LegsDefined.prj** contains all of these definitions and can be used as a starting point for the next set of definitions for the torso.

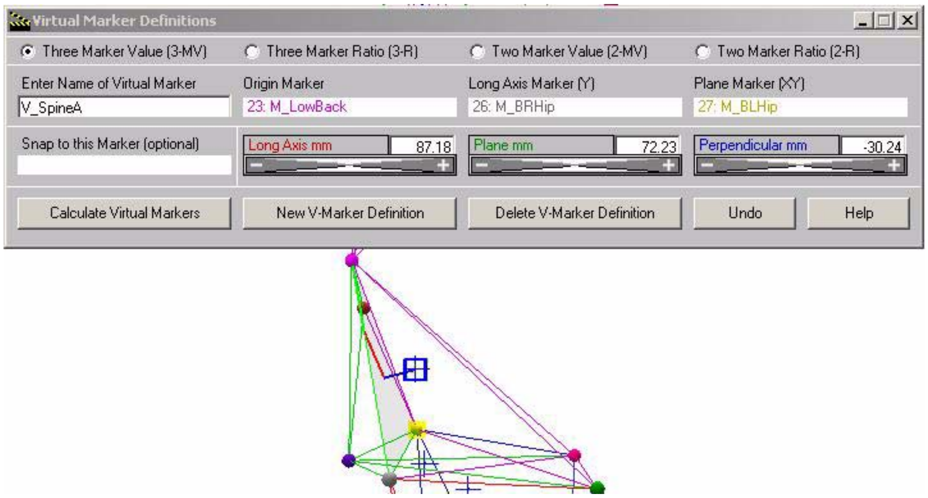
Torso

The next major step in defining virtual markers is to work up the entire length of the torso along the spine. It is important (particularly in the Skeleton Builder process) for the virtual markers of the spine NOT to be in a perfectly straight line. It's best to try and follow the natural curvature of the spine. For the skeleton later, this allows some "give" in the motion of the skeleton to allows it to better track the motion of the performer without undue stretching of the bones.

Spinal Segments

Each of the spine virtual makers are defined in a similar fashion. The naming convention will be a little different, each of the spine virtual markers will be named in an alphabetical sequence (V_SpineA, V_SpineB, etc...). This is similar to common practices used in skeleton definitions in animation systems.

Figure 11-24. Virtual Marker Definition for V_SpineA

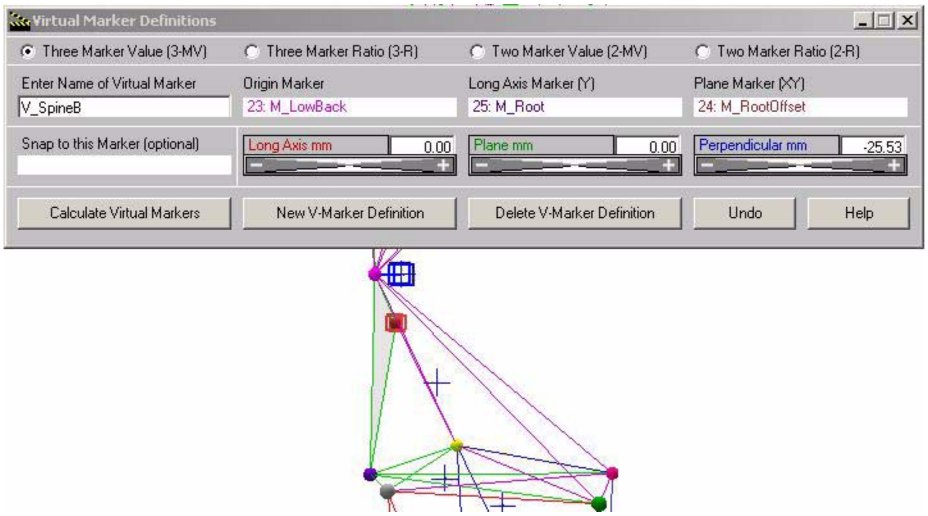

Virtual Marker Definitions
Calculate Virtual Markers
New V-Marker Definition
Delete V-Marker Definition
Undo
Help

● Three Marker Value (3-MV) ○ Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_SpineA
Origin Marker: 23: M_LowBack
Long Axis Marker (Y): 26: M_BRHip
Plane Marker (XY): 27: M_BLHip
Snap to this Marker (optional):
Long Axis mm: 87.18
Plane mm: 72.23
Perpendicular mm: -30.24

The definition for V_SpineA is intended to represent the arch in the small of the back (relative to the pending definition of V_SpineB).

Figure 11-25. Virtual Marker Definition for V_SpineB

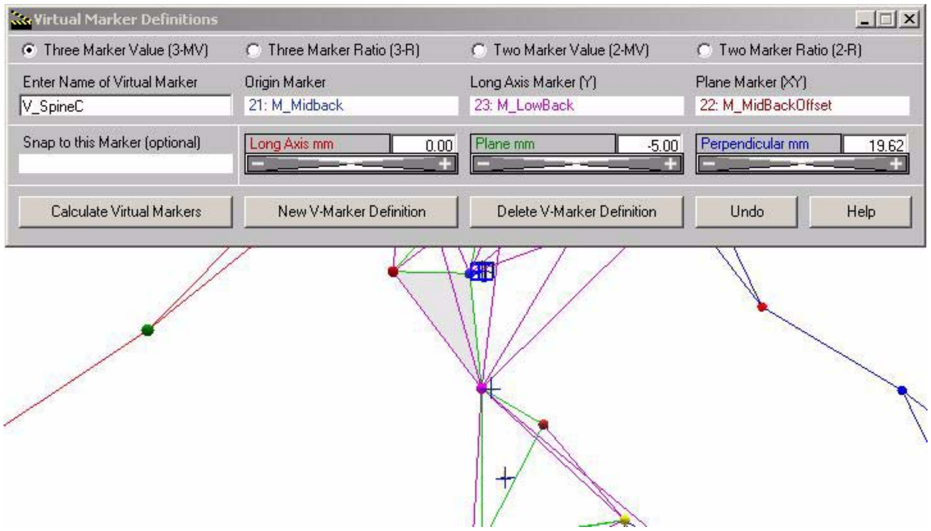

Virtual Marker Definitions
Calculate Virtual Markers
New V-Marker Definition
Delete V-Marker Definition
Undo
Help

● Three Marker Value (3-MV) ○ Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_SpineB
Origin Marker: 23: M_LowBack
Long Axis Marker (Y): 25: M_Root
Plane Marker (XY): 24: M_RootOffset
Snap to this Marker (optional):
Long Axis mm: 0.00
Plane mm: 0.00
Perpendicular mm: -25.53

Continuing on to V_SpineC and the "S" shape for the spine:

Figure 11-26. Virtual Marker Definition for V_SpineC

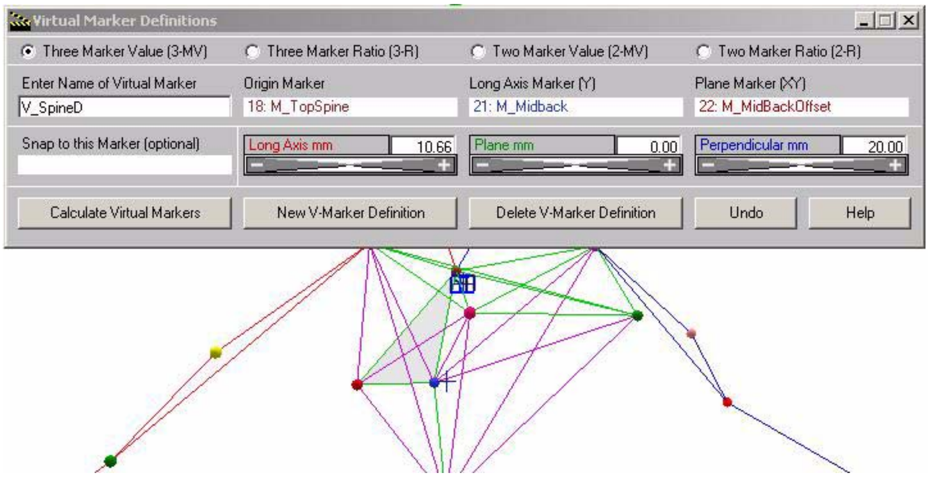

● Three Marker Value (3-MV) ○ Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_SpineC
Origin Marker: 21: M_Midback
Long Axis Marker (Y): 23: M_LowBack
Plane Marker (XY): 22: M_MidBackOffset
Snap to this Marker (optional):
Long Axis mm: 0.00
Plane mm: -5.00
Perpendicular mm: 19.62

Virtual Marker Definitions
Calculate Virtual Markers
New V-Marker Definition
Delete V-Marker Definition
Undo
Help

Note that a small left-right adjustment was made to V_SpineC to keep the spine aligned. Continuing on to V_SpineD and the "S" shape for the spine:

Figure 11-27. Virtual Marker Definition for V_SpineD


● Three Marker Value (3-MV) ○ Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_SpineD
Origin Marker: 18: M_TopSpine
Long Axis Marker (Y): 21: M_Midback
Plane Marker (XY): 22: M_MidBackOffset
Snap to this Marker (optional):
Long Axis mm: 10.66
Plane mm: 0.00
Perpendicular mm: 20.00

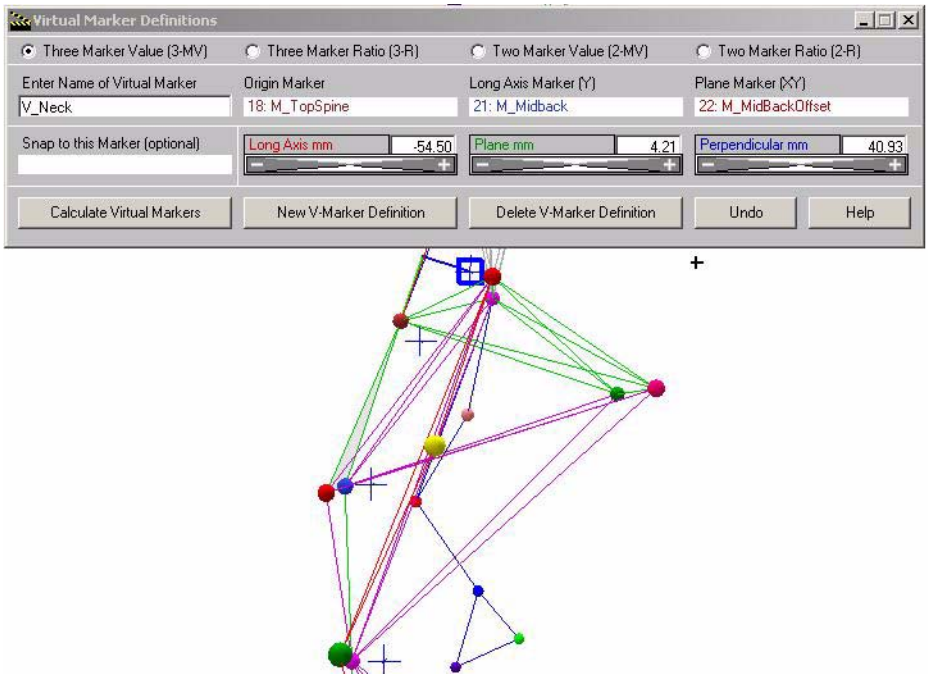
Virtual Marker Definitions
Calculate Virtual Markers
New V-Marker Definition
Delete V-Marker Definition
Undo
Help

To keep a little distance from the upcoming V_Neck definition, the position of V_SpineD was moved down slightly.

Neck

The neck is the end point of the spine definitions. As such it follows, and finishes, the "S" shape of the spine. Notice that it slopes almost as far forward as it does up. This is intentional and could be accentuated even more.

Figure 11-28. Virtual Marker Definition for V_Neck


Virtual Marker Definitions
Calculate Virtual Markers
New V-Marker Definition
Delete V-Marker Definition
Undo
Help

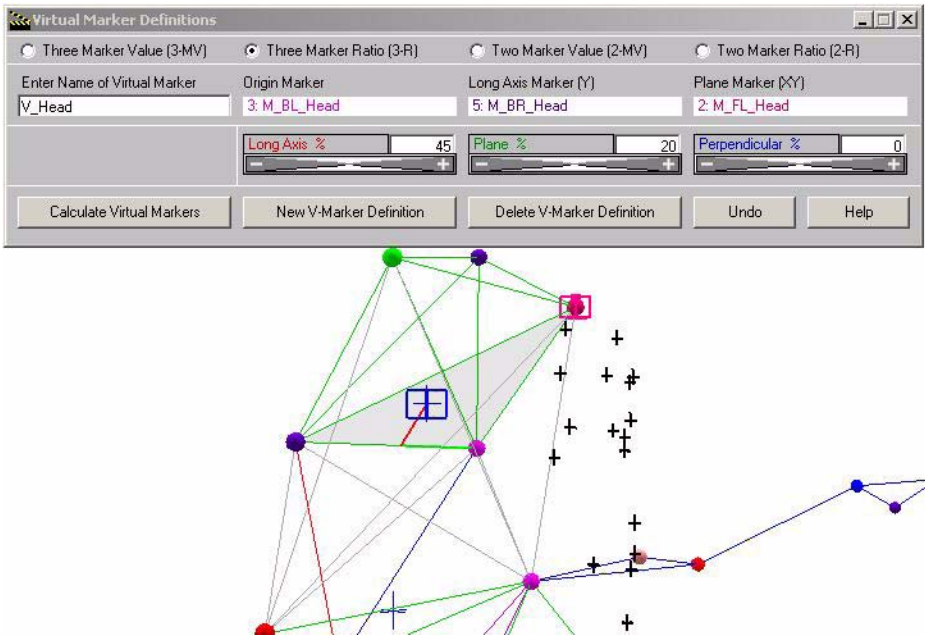
● Three Marker Value (3-MV) ○ Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_Neck
Origin Marker: 18: M_TopSpine
Long Axis Marker (Y): 21: M_Midback
Plane Marker (XY): 22: M_MidBackOffset
Snap to this Marker (optional):
Long Axis mm: -54.50
Plane mm: 4.21
Perpendicular mm: 40.93

Head

The V_Head marker definition is designed so that while the performer's head is upright the position of the V_Head marker relative to the V_Neck marker will also be upright. This is different from earlier attempts to put a virtual marker at a joint location, here the V_Head marker rests on what would be roughly where the back of the performer's head is. The idea is that as an end effector, the orientation of the head segment (as will be defined by Skeleton Builder) is more important than the actual location of the joint so its relationship to the neck joint is more important.

Figure 11-29. Virtual Marker Definition for V_Head



○ Three Marker Value (3-MV) ● Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_Head
Origin Marker: 3: M_BL_Head
Long Axis Marker (Y): 5: M_BR_Head
Plane Marker (XY): 2: M_FL_Head
Long Axis %: 45
Plane %: 20
Perpendicular %: 0

Virtual Marker Definitions
Calculate Virtual Markers
New V-Marker Definition
Delete V-Marker Definition
Undo
Help

Note that this is the first time the Three Marker Ratio type is used. When trying to get a central location for a virtual marker this type of definition can be very handy.

The sample project file **Dave_LegsTorsoDefined.prj** has all of the virtual marker definitions described so far. You can start with that project to move on to the next step.

Each Arm

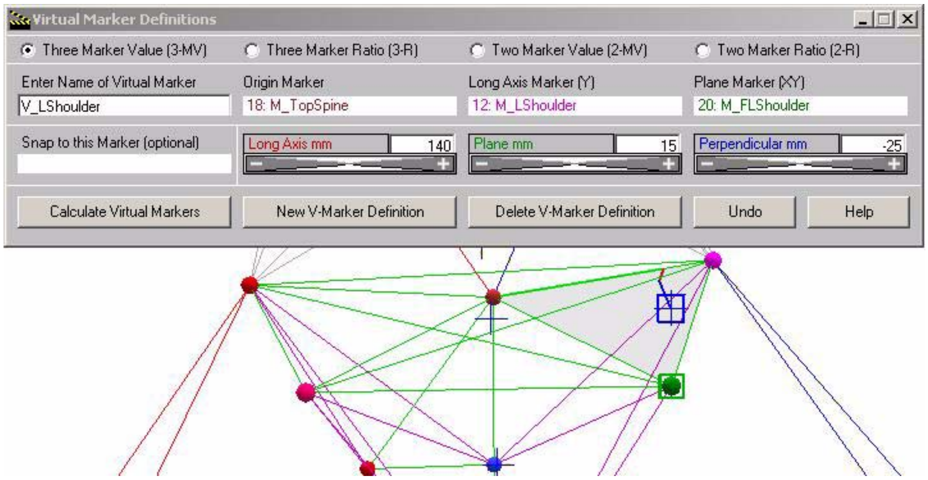
The definitions for each arm are symmetric so only the virtual markers for the left arm are described here.

Shoulder

Getting a good virtual marker definition for the shoulder joint is vital to getting natural looking motion for the arms. The difficulty here is that the M_LShoulder and M_RShoulder markers, being located on the top of the shoulders of the performer, rotate far on the outside of the shoulder joint. Therefore they have a large amount of translation data. You can see this by playing through frames 900 to 1050 of the tracks file **Dave_ROM1.trb**. Note the distance of the shoulder markers from each other- when the arms are raised the markers are much closer to each other than when the arms are down. It's important to eliminate this disparity to get a good representation of clavicle motion in the Skeleton Builder definition.

Fortunately this is easy to obtain by a proper definition of the virtual markers. In this case the Origin marker is specified as the M_Neck marker and the type of definition is the Three Marker Value. This ensures that the location of the virtual marker are a set distance from the M_Neck marker. Small adjustments to the Plane and Perpendicular numerical inputs place the marker approximately at the actual shoulder joint location.

Figure 11-30. Virtual Marker Definition for V_LShoulder



Virtual Marker Definitions

● Three Marker Value (3-MV) ○ Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_LShoulder

Origin Marker: 18: M_TopSpine

Long Axis Marker (Y): 12: M_LShoulder

Plane Marker (XY): 20: M_FLShoulder

Snap to this Marker (optional):

Long Axis mm: 140

Plane mm: 15

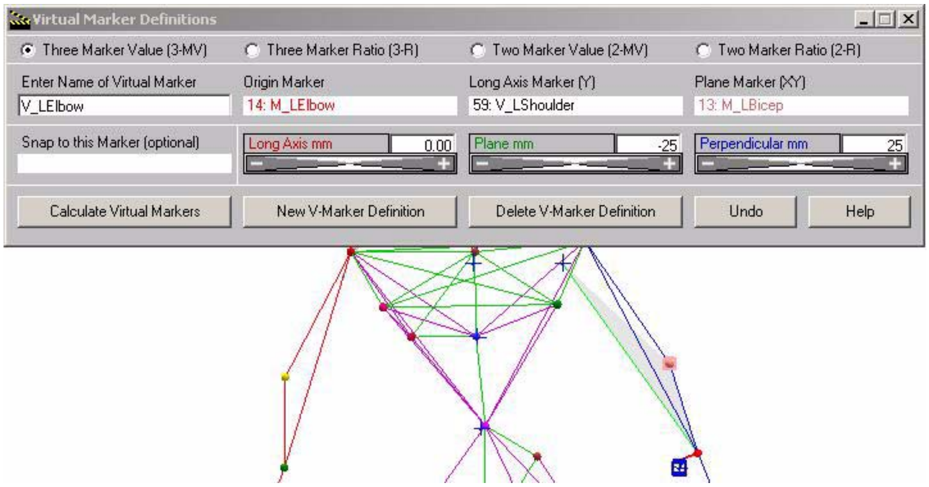
Perpendicular mm: -25

Look again at frames 900-1050. You will see that the V_LShoulder joint stays a constant distance from the V_Neck marker.

Elbow

The definition of the V_LElbow marker is constructed to place it at the center of the actual elbow joint.

Figure 11-31. Virtual Marker Definition for V_LElbow


Virtual Marker Definitions
○ Three Marker Ratio (3-R)
○ Two Marker Value (2-MV)
○ Two Marker Ratio (2-R)
Calculate Virtual Markers
New V-Marker Definition
Delete V-Marker Definition
Undo
Help

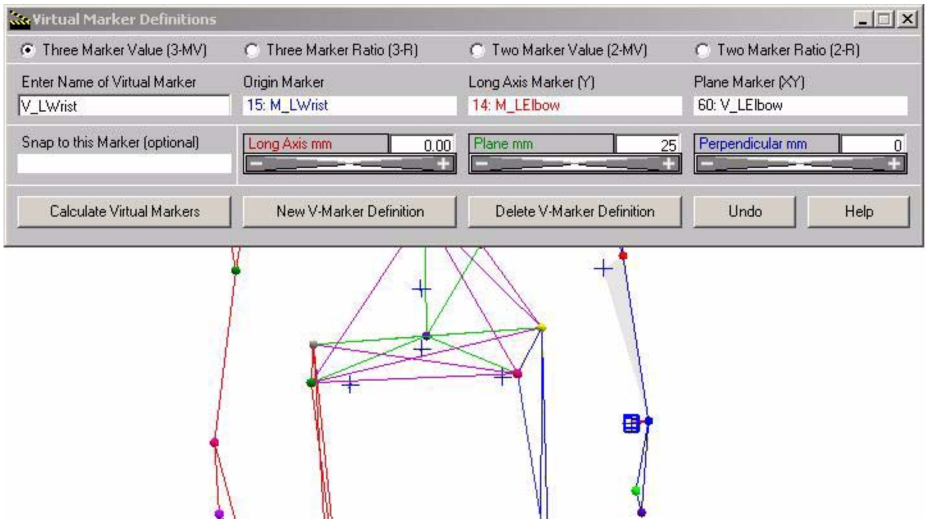
● Three Marker Value (3-MV)

Enter Name of Virtual Marker: V_LElbow
Origin Marker: 14: M_LElbow
Long Axis Marker (Y): 59: V_LShoulder
Plane Marker (XY): 13: M_LBicep
Snap to this Marker (optional):
Long Axis mm: 0.00
Plane mm: -25
Perpendicular mm: 25

Wrist

The definition of the V_LWrist marker is constructed to place it at the center of the actual wrist joint.

Figure 11-32. Virtual Marker Definition for V_LWrist


Virtual Marker Definitions
○ Three Marker Ratio (3-R)
○ Two Marker Value (2-MV)
○ Two Marker Ratio (2-R)
Calculate Virtual Markers
New V-Marker Definition
Delete V-Marker Definition
Undo
Help

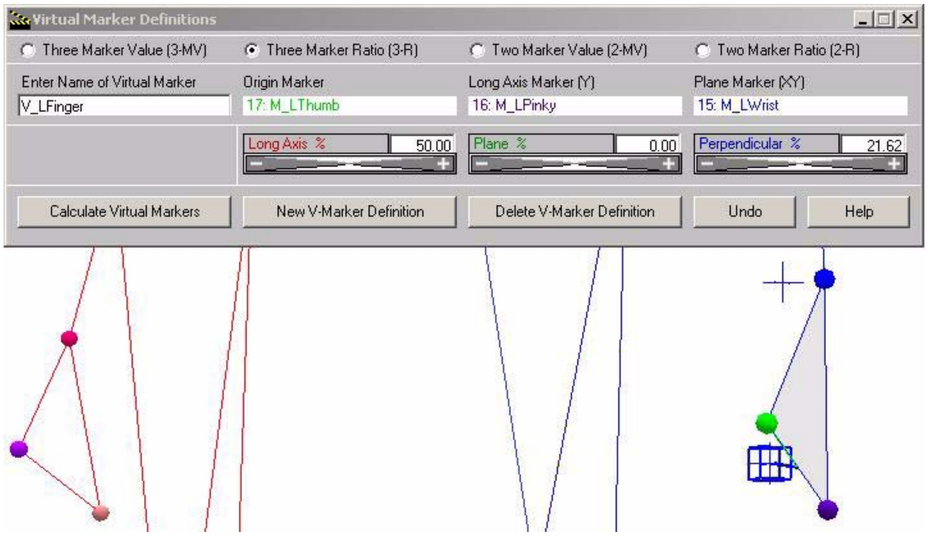
● Three Marker Value (3-MV)

Enter Name of Virtual Marker: V_LWrist
Origin Marker: 15: M_LWrist
Long Axis Marker (Y): 14: M_LElbow
Plane Marker (XY): 60: V_LElbow
Snap to this Marker (optional):
Long Axis mm: 0.00
Plane mm: 25
Perpendicular mm: 0

Finger

The definition of the V_LFinger marker, despite the name, is really constructed to place it at the center of the knuckles on the left hand.

Figure 11-33. Virtual Marker Definition for V_LFinger



Virtual Marker Definitions

○ Three Marker Value (3-MV) ● Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_LFinger
Origin Marker: 17: M_LThumb
Long Axis Marker (Y): 16: M_LPinky
Plane Marker (XY): 15: M_LWrist
Long Axis %: 50.00
Plane %: 0.00
Perpendicular %: 21.62

Note the use of the Three Marker Ratio type of definition. This makes it easy to place the marker right in the middle of the thumb and pinky markers.

After completing the right arm the construction of the virtual marker definitions for this project is complete. The sample project file **Dave_FullyDefined.prj** contains the definitions of all the virtual markers.

Lost Marker Example

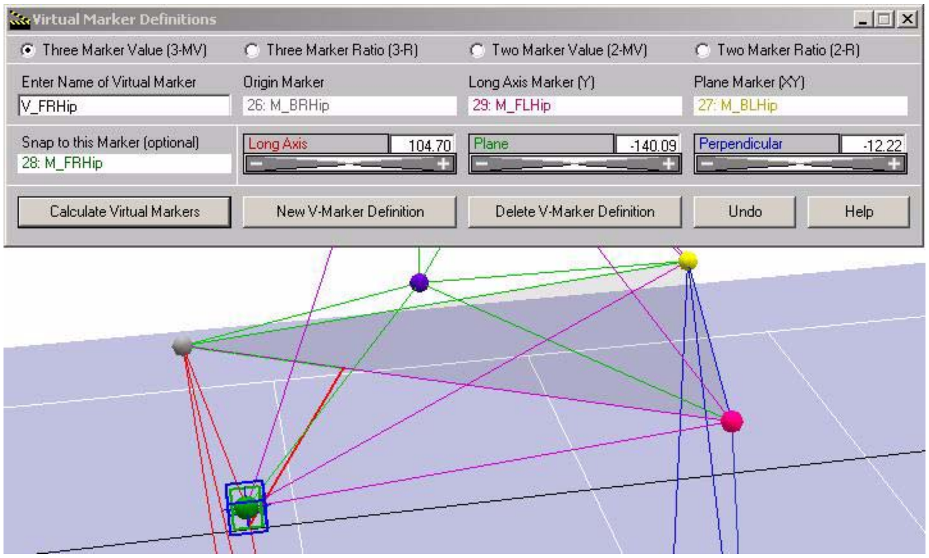
There are times, despite the best diligence of the motion capture personnel, when a marker falls off of a performer and the fact isn't noted until some time afterward. When this happens, a series of trials will be made with an incomplete data set. Trials that are, except for the missing marker, good. It is for this circumstance that a particular feature of virtual markers is very useful.

This example takes advantage of the fact that at some time during the motion capture session the missing marker was still attached to the performer. A trial containing the marker will be used to construct a virtual marker that will replace it in the trials where the marker is missing. It isn't possible to use Join Virtual to fix this problem because Join Virtual requires that the gapped marker exist in the same trial either before or after the gap that is being filled in.

In the sample data directory there are two TRB files: **Trial_12.trb** and **Trial_13.trb**. Trial_12 contains all the markers. Trial_13 has a missing front right hip marker. The following sequence of steps will use a virtual marker definition to fill in the missing marker in Trial_13 by constructing the virtual marker in Trial_12 using the Snap to this Marker feature.

1. Start EVaRT and load the project **Dave_Fresh.prj**.
2. Load the tracks file **Trial_12.trb**.
3. Construct the virtual maker V_FRHip.

Figure 11-34. Virtual Marker Definition for V_FRHip



Virtual Marker Definitions

● Three Marker Value (3-MV) ○ Three Marker Ratio (3-R) ○ Two Marker Value (2-MV) ○ Two Marker Ratio (2-R)

Enter Name of Virtual Marker: V_FRHip

Origin Marker: 26: M_BRHip

Long Axis Marker (Y): 29: M_FLHip

Plane Marker (XY): 27: M_BLHip

Snap to this Marker (optional): 28: M_FRHip

Long Axis: 104.70

Plane: -140.09

Perpendicular: -12.22

The virtual marker definition uses the Snap to this Marker to automatically calculate the numerical values necessary to place the virtual marker at the same location as the actual marker.

1. Load the tracks file **Trial_13.trb**.
2. Select the **Calculate Virtual Markers** button in the **Post Process** sub-panel.
3. From the marker list, select the marker **M_FRhip**.
4. From the **Post Process** panel, press **Marker ID...**
5. With the entire frame range selected, select the virtual marker **V_FRHip** in the 3D display.

The missing M_FRHip marker has now been filled in with data from the virtual marker and this can be saved to a new TRB file.

Chapter 12 User Apps Panel

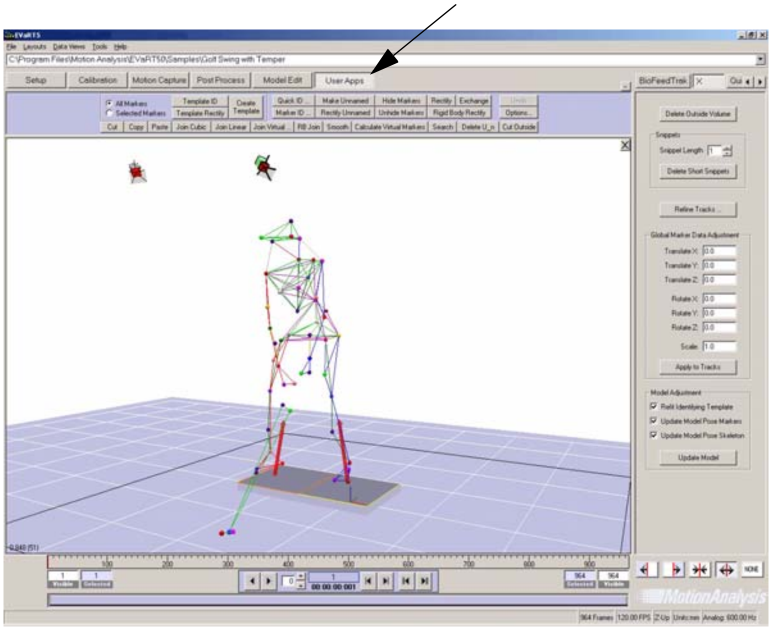
Topic	Page
Overview	12-1
X Sub-Panel	12-2
Sky Sub-Panel	12-5
Motion Composer Sub-Panel	12-6
BioFeedTrak Sub-Panel	12-7
QuickDB Sub-Panel	12-9

Overview

The User Apps panel houses the plugins for the **EVaRT** user interface. These plugins include:

- X
- Sky Writer
- Motion Composer
- BioFeedTrak
- QuickDB

Figure 12-1. The User Apps Mode

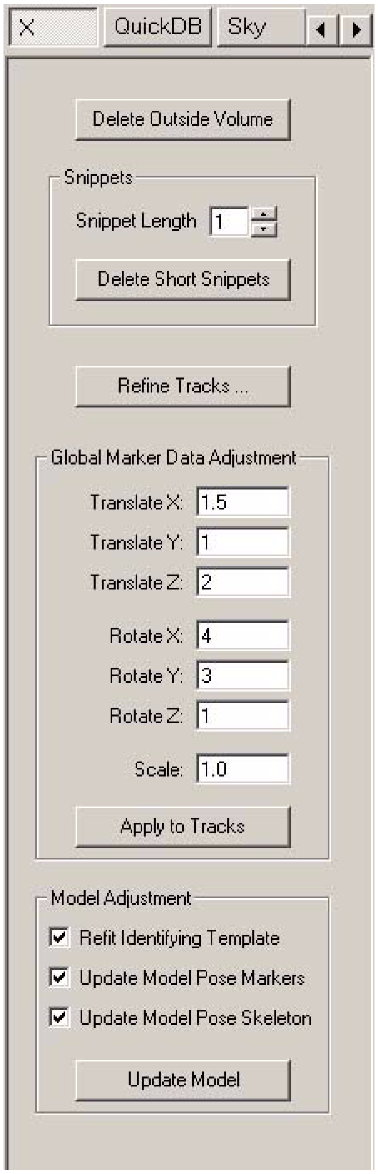


EVaRT5
File Layouts Data Views Tools Help
C:\Program Files\Motion Analysis\EVaRT50\Samples\Golf Swing with Temper
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
BioFeedTrak
All Markers
Selected Markers
Template ID
Template Rectify
Create Template
Quick ID ...
Marker ID ...
Make Unnamed
Rectify Unnamed
Hide Markers
Unhide Markers
Rectify
Exchange
Rigid Body Rectify
Undo
Options...
Cut
Copy
Paste
Join Cubic
Join Linear
Join Virtual ...
RB Join
Smooth
Calculate Virtual Markers
Search
Delete U_n
Cut Outside
Delete Outside Volume
Snippets
Snippet Length
Delete Short Snippets
Refine Tracks ...
Global Marker Data Adjustment
Apply to Tracks
Model Adjustment
Update Model
MotionAnalysis

X Sub-Panel

The X sub-panel provides a set of extra functions that are used in the post process mode.

Figure 12-2. X Sub-Panel


X
QuickDB
Sky
Delete Outside Volume
Snippets
Delete Short Snippets
Refine Tracks ...
Global Marker Data Adjustment
Apply to Tracks
Model Adjustment
Update Model

Snippet Length: 1

Translate X: 1.5
Translate Y: 1
Translate Z: 2

Rotate X: 4
Rotate Y: 3
Rotate Z: 1

Scale: 1.0

☑ Refit Identifying Template
☑ Update Model Pose Markers
☑ Update Model Pose Skeleton

Delete Outside Volume

Eliminates all marker data outside of the volume defined in Calibration Details.

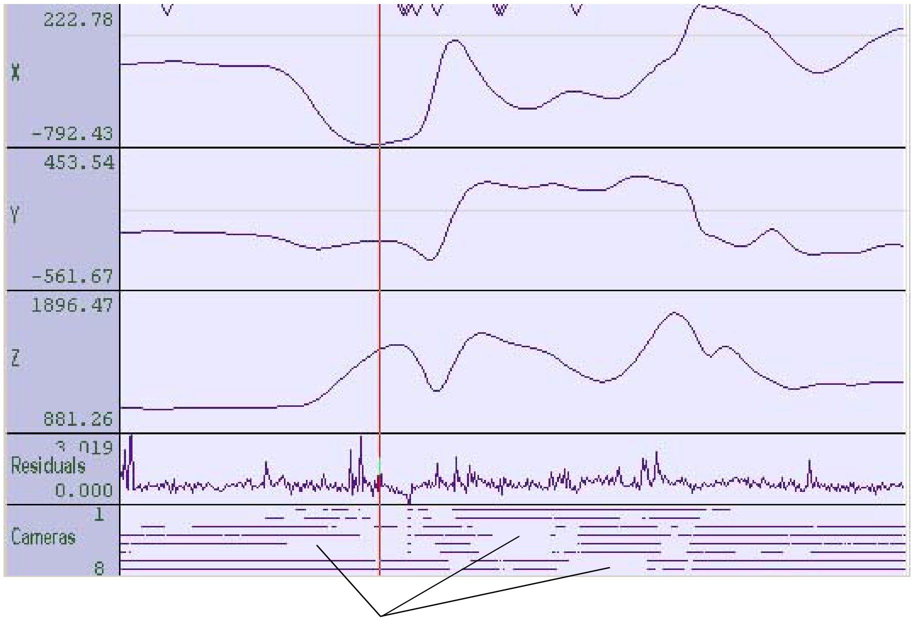
Snippets/Delete Short Snippets

Deletes data strings (in frames) that are shorter than a specified length.

Refine Tracks

This feature will smooth data that has become jumpy due to camera on/off noise. When a camera is turned on and off, there is at times a small data spike in the frames before the camera is turned off and after it is on. This is useful on facial data where small increments (< 1 mm) will have a significant effect on the final results (animated character).

Figure 12-3. Refine Tracks



Missing data to be smoothed

To Refine Tracks you will need to:

1. Load a ***.prj** file.
2. Load a ***.trb** file.
3. Select **File > Load VC for Post**.
4. Click-on **Refine Tracks**.
5. Select **File > Save Tracks**.

Global Marker Data Adjustments

The Global Marker Data Adjustment section allows the user to modify the tracks data by translating, rotating, and/or scaling the data. This is an operation that applies to all marker data over all the tracks. It's especially handy for converting the overall orientation of the data (such as from a Z-up coordinate system to a Y-up coordinate system).

Model Adjustments

The Model Adjustment section allows the user to update the Calcium Solver model pose data and the template model pose data simultaneously (this is the data displayed when the Show Model Pose flag is on). The marker data in the model pose is used for two different operations: as a starting pose for the template when doing a New Subject operation; and as the matching base pose for the skeleton in the Calcium Solver model. Doing both adjustments at once is important to maintaining the integrity of the data. None the less, the user is allowed to change them independently if necessary.

Refit Identifying Template—This option takes the current frame in Post Process and compares the template linkage lengths of that frame with the stored model pose. The template Min/Max values are re-calculated based on the amount of change in the linkage lengths.

Update Model Pose Markers—This checkbox indicates that the stored marker model pose is to be replaced with the marker data on the current frame.

Update Model Pose Skeleton—This checkbox indicates that the stored skeleton model pose is to be replaced with the current skeleton data that has been calculated for the current frame.

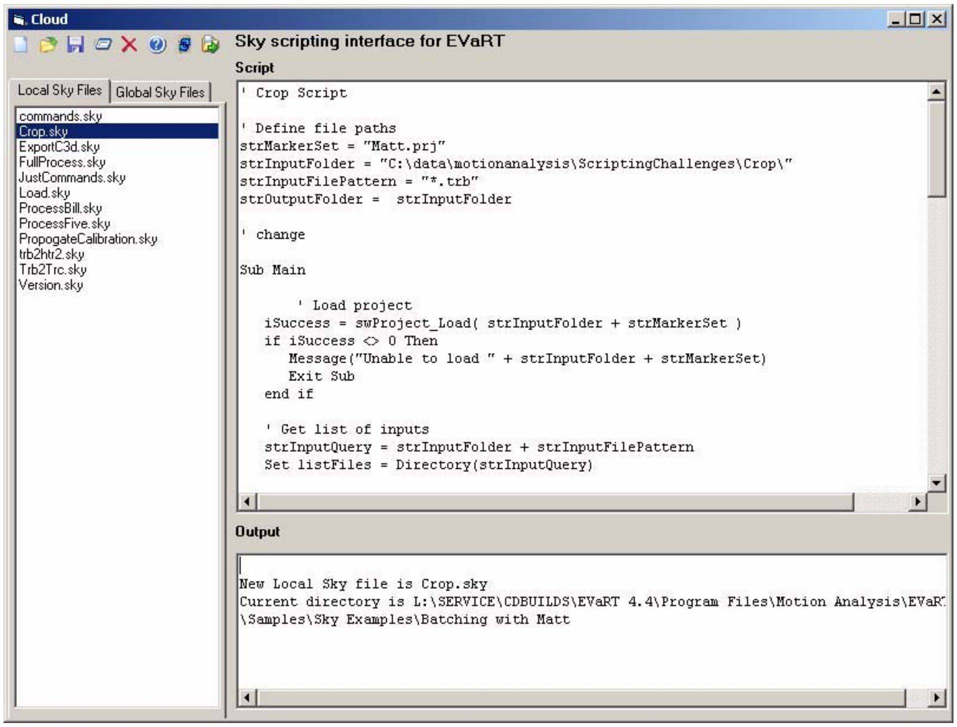
These last two options are used to update the model pose of a performer between motion capture sessions (such as from one day to the next). This avoids having to spend time refitting the position of the skeleton to the new day's model pose data. The user should still verify that the fit is a good one, but if the markers on the performer have not moved by very much then the fit is likely to be good.

Sky Sub-Panel

Sky Writer is the name of the scripting interface for **EVaRT**. It uses the VB Script engine to provide the semantic structure of the language along with Visual Basic to provide the graphical user interface of the window pane. Sky (Writer) is intended as a tool for users to encapsulate elements of repetitive tasks such as file processing, data editing and parameter setting. This tool is intended for users who have some general knowledge of scripting and programming.

For more information refer to Chapter 14, Sky Writer and visit www.EVaRT-Forum.com <http://www.evart-forum.com/>.

Figure 12-4. Sky Scripting Interface


Cloud
Sky scripting interface for EVaRT
Script
Local Sky Files
Global Sky Files
commands.sky
Crop.sky
ExportC3d.sky
FullProcess.sky
JustCommands.sky
Load.sky
ProcessBill.sky
ProcessFive.sky
PropogateCalibration.sky
trb2htr2.sky
Trb2Trc.sky
Version.sky
Output

```
' Crop Script

' Define file paths
strMarkerSet = "Matt.prj"
strInputFolder = "C:\data\motionanalysis\ScriptingChallenges\Crop\"
strInputFilePattern = "*.trb"
strOutputFolder =  strInputFolder

' change

Sub Main

       ' Load project
   iSuccess = swProject_Load( strInputFolder + strMarkerSet )
   if iSuccess <> 0 Then
      Message("Unable to load " + strInputFolder + strMarkerSet)
      Exit Sub
   end if

   ' Get list of inputs
   strInputQuery = strInputFolder + strInputFilePattern
   Set listFiles = Directory(strInputQuery)
```

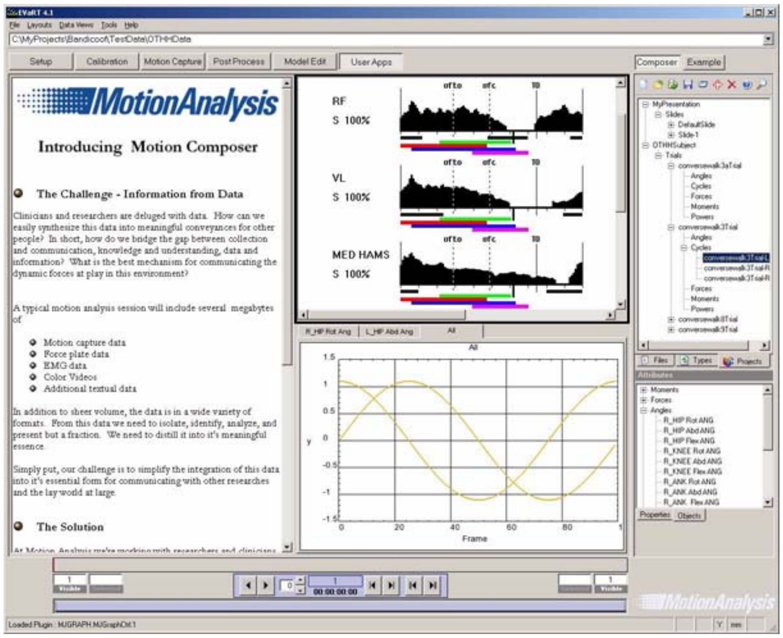
```
New Local Sky file is Crop.sky
Current directory is L:\SERVICE\CDBUILDS\EVaRT 4.4\Program Files\Motion Analysis\EVaR
\Samples\Sky Examples\Batching with Matt
```

Motion Composer Sub-Panel

Motion Composer is a suite of tools for collating, integrating, and presenting interactive motion capture data. Motion Composer is a collection of authoring tools, data structures, and visualization panes. These are integrated into **EVaRT** to help achieve a seamless workflow for the user to package and present a motion capture session. Some of the key features to be found in Motion Composer include:

- Integrated Authoring
- Interactive Player
- Rich Media Support
- Presentation Tools

Figure 12-5. Motion Composer Interface



EVaRT 4.1
File Layouts Data Views Tools Help
C:\MyProjects\Bandicoot\TestData\OTHHData
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
MotionAnalysis
RF
S 100%
VL
S 100%
MED HAMS
S 100%
ofto
ofc
R_HIP Rot Ang
L_HIP Abd Ang
All
1.5
1
0.5
0
-0.5
-1
-1.5
y
0
20
40
60
80
Frame
Composer
Example
MyPresentation
Slides
DefaultSlide
Slide-1
OTHHSubject
Trials
conversewalk3aTrial
Angles
Cycles
Forces
Moments
Powers
conversewalk3Trial
conversewalk8Trial
conversewalk9Trial
Files
Types
Projects
Attributes
R_HIP Rot ANG
R_HIP Abd ANG
R_HIP Flex ANG
R_KNEE Rot ANG
R_KNEE Abd ANG
R_KNEE Flex ANG
R_ANK Rot ANG
R_ANK Abd ANG
R_ANK Flex ANG
Properties
Objects
Visible
Loaded Plugin : MJGRAPH.MJGraphCtrl.1

Introducing Motion Composer

The Challenge - Information from Data

Clinicians and researchers are deluged with data. How can we easily synthesize this data into meaningful conveyances for other people? In short, how do we bridge the gap between collection and communication, knowledge and understanding, data and information? What is the best mechanism for communicating the dynamic forces at play in this environment?

A typical motion analysis session will include several megabytes of

- Motion capture data
- Force plate data
- EMG data
- Color Videos
- Additional textual data

In addition to sheer volume, the data is in a wide variety of formats. From this data we need to isolate, identify, analyze, and present but a fraction. We need to distill it into it's meaningful essence.

Simply put, our challenge is to simplify the integration of this data into it's essential form for communicating with other researches and the lay world at large.

The Solution

At Motion Analysis we're working with researchers and clinicians

BioFeedTrak Sub-Panel

BioFeedTrak is a general condition, evaluation, and response program, integrated into **EVaRT**, for designing and implementing biofeedback programs that can enable clinicians and patients to receive instantaneous audio feedback to kinematic movements. **BioFeedTrak** is able to give real-time feedback in the form of sounds based on kinetic variables that fall within certain bounds during the pre-defined performance of any type of physical task.

Kinematic variables include position, velocity and acceleration of individual markers (up to 45 markers) placed on key anatomical points of interest. Included angle between three markers as well as the angle of inclination of a segment defined by two markers can be used to provide feedback. Kinetic data include the following:

- horizontal and vertical forces
- moment about the vertical axis
- the coordinates of the center of pressure with respect to the forceplates

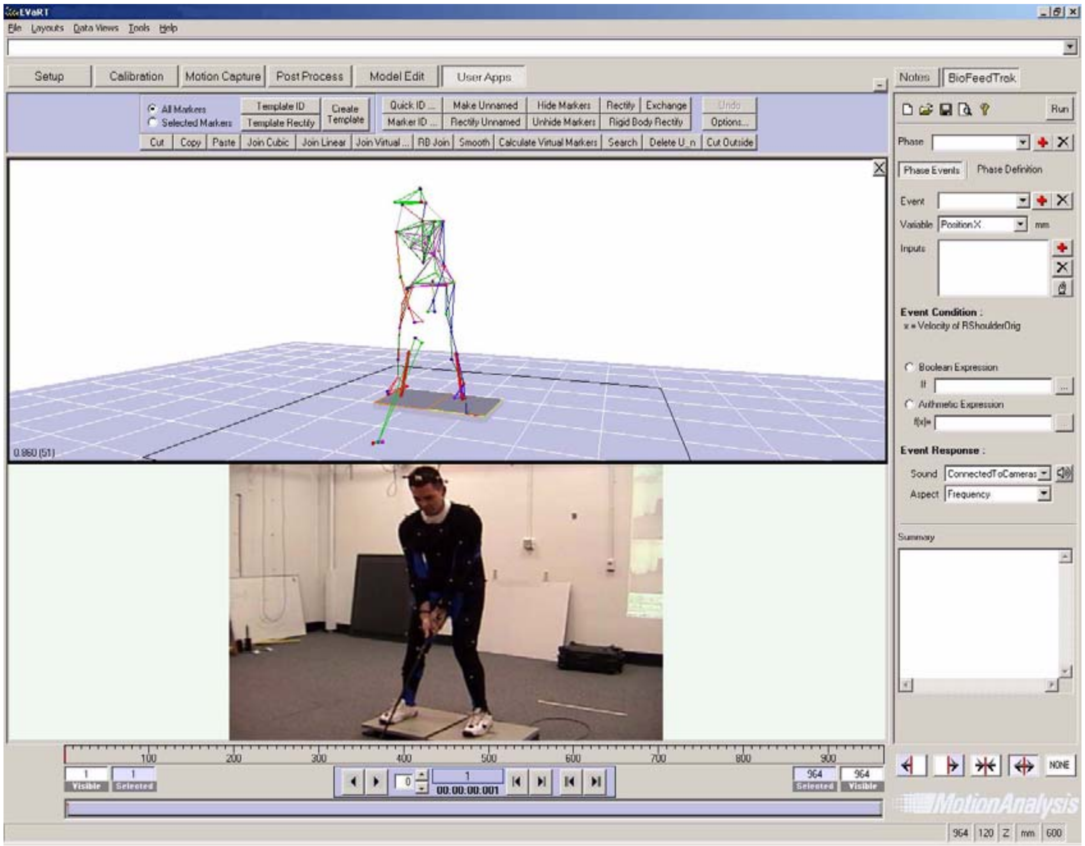
The program works in conjunction with the Motion Analysis Eagle Digital System or the Falcon Analog System. For a typical application procedure, the user will do the following:

1. Choose and set the variables to be monitored
2. Determine the starting and ending parameters for each variable to be assessed
3. Choose the volume and frequency of the audio feedback
4. Start the Real-Time system

With this, the patient and clinician are able to work side by side to retrain areas of the body that need further optimization.

More information may be found in the *BioFeedTrak Quick-Start Guide*.

Figure 12-6. BioFeedTrak Interface


EVaRT
File Layouts Data Views Tools Help
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
All Markers
Selected Markers
Template ID
Template Rectify
Create Template
Quick ID ...
Marker ID ...
Make Unnamed
Rectify Unnamed
Hide Markers
Unhide Markers
Rectify
Exchange
Rigid Body Rectify
Undo
Options...
Cut
Copy
Paste
Join Cubic
Join Linear
Join Virtual ...
RB Join
Smooth
Calculate Virtual Markers
Search
Delete U_n
Cut Outside
0.860 (51)
Notes
BioFeedTrak
Run
Phase
Phase Events
Phase Definition
Event
Inputs
Boolean Expression
Arithmetic Expression
Summary
Visible
Selected
Selected
Visible
NONE
MotionAnalysis
964
120
Z
mm
600

Variable Position X mm

Event Condition :
x = Velocity of RShoulderOrig

Event Response :
Sound ConnectedToCameras
Aspect Frequency

QuickDB Sub-Panel

QuickDB is an integrated database tool for **EVaRT** that allows the user to easily track all **EVaRT** project information. Microsoft Access databases are used to tabulate information about your projects (a copy of Microsoft Access is not required to take advantage of this tool). A master database keeps a list of all the individual projects you make. Each individual project (called a "session list") keeps track of all the data associated with a specific project directory (project files, VC files, tracks files, etc...). It is fast and easy to create a session list of any data you already have. QuickDB will scan your project directory for the data you have already collected and will create the session database for you.

QuickDB is all of the following:

- Is very handy for keeping track of all your projects, you can scan for and then load project data with ease.
- Will record your trials as you collect data.
- Contains tracking information about a trial's Post Process status.
- Allow's multiple user access to shared session databases.
- Makes it easy to share databases with other users.
- Allows the creation of capture lists ahead of time so that capture names can be loaded from QuickDB while recording a session.
- Is an SQL database that can be used to generate reports on project status.

Figure 12-7. User Apps > QuickDB Sub-Panel

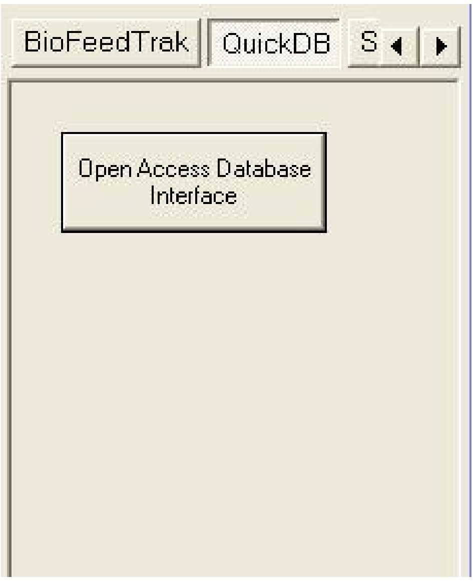
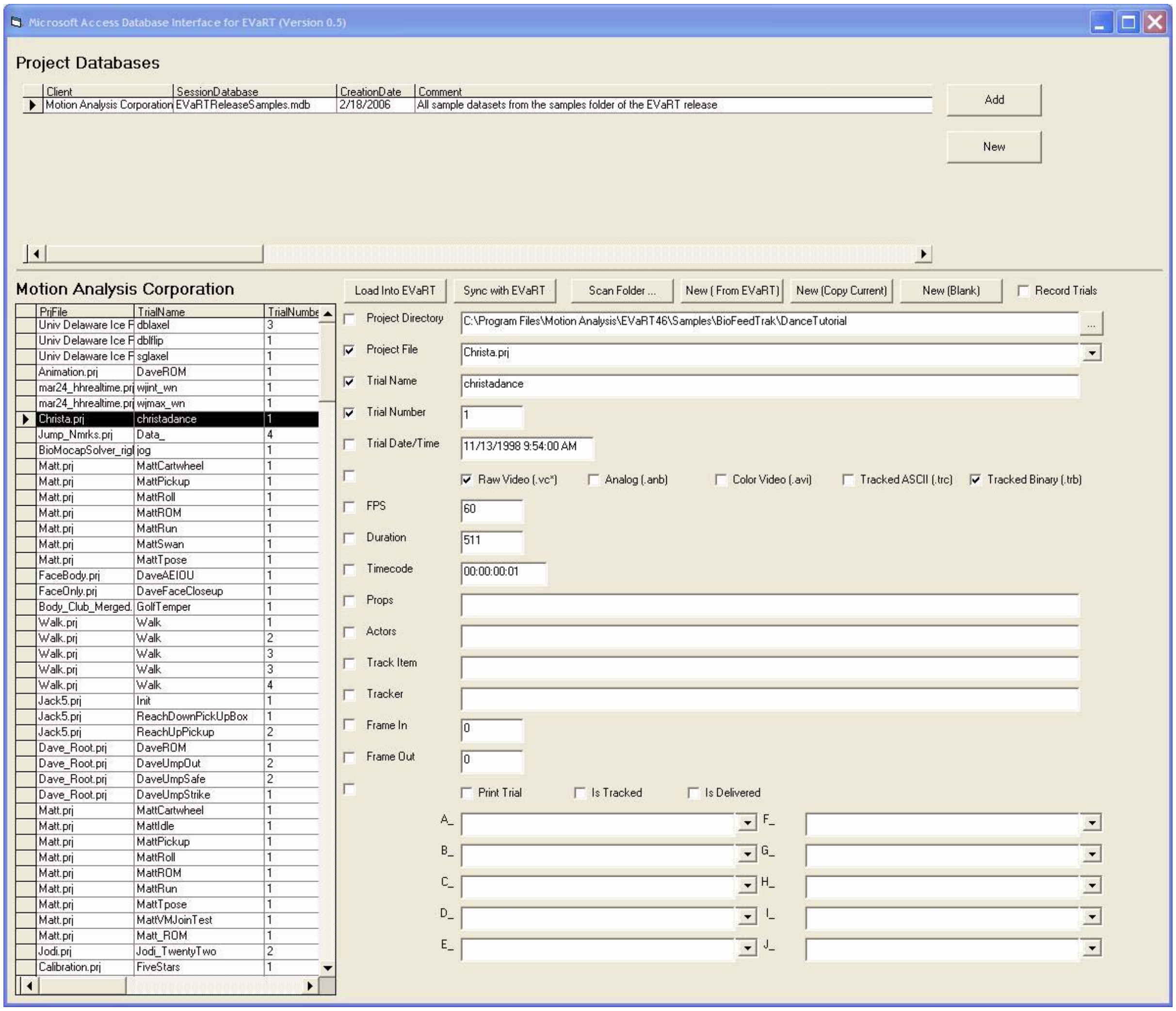


Figure 12-8. QuickDB Interface



Project Databases

Client	SessionDatabase	CreationDate	Comment
Motion Analysis Corporation	EVaRTReleaseSamples.mdb	2/18/2006	All sample datasets from the samples folder of the EVaRT release

Motion Analysis Corporation

PrjFile	TrialName	TrialNumbe
Univ Delaware Ice F	dblaxel	3
Univ Delaware Ice F	dblflip	1
Univ Delaware Ice F	sglaxel	1
Animation.prj	DaveROM	1
mar24_hhrealtime.prj	wjint_wn	1
mar24_hhrealtime.prj	wjmax_wn	1
Christa.prj	christadance	1
Jump_Nmrks.prj	Data_	4
BioMocapSolver_rigl	jog	1
Matt.prj	MattCartwheel	1
Matt.prj	MattPickup	1
Matt.prj	MattRoll	1
Matt.prj	MattROM	1
Matt.prj	MattRun	1
Matt.prj	MattSwan	1
Matt.prj	MattTpose	1
FaceBody.prj	DaveAEIOU	1
FaceOnly.prj	DaveFaceCloseup	1
Body_Club_Merged.	GolfTemper	1
Walk.prj	Walk	1
Walk.prj	Walk	2
Walk.prj	Walk	3
Walk.prj	Walk	3
Walk.prj	Walk	4
Jack5.prj	Init	1
Jack5.prj	ReachDownPickUpBox	1
Jack5.prj	ReachUpPickup	2
Dave_Root.prj	DaveROM	1
Dave_Root.prj	DaveUmpOut	2
Dave_Root.prj	DaveUmpSafe	2
Dave_Root.prj	DaveUmpStrike	1
Matt.prj	MattCartwheel	1
Matt.prj	MattIdle	1
Matt.prj	MattPickup	1
Matt.prj	MattRoll	1
Matt.prj	MattROM	1
Matt.prj	MattRun	1
Matt.prj	MattTpose	1
Matt.prj	MattVMJoinTest	1
Matt.prj	Matt_ROM	1
Jodi.prj	Jodi_TwentyTwo	2
Calibration.prj	FiveStars	1

☐ Project Directory C:\Program Files\Motion Analysis\EVaRT46\Samples\BioFeedTrak\DanceTutorial
☑ Project File Christa.prj
☑ Trial Name christadance
☑ Trial Number 1
☐ Trial Date/Time 11/13/1998 9:54:00 AM
☐ ☑ Raw Video (.vc*) ☐ Analog (.anb) ☐ Color Video (.avi) ☐ Tracked ASCII (.trc) ☑ Tracked Binary (.trb)
☐ FPS 60
☐ Duration 511
☐ Timecode 00:00:00:01
☐ Props
☐ Actors
☐ Track Item
☐ Tracker
☐ Frame In 0
☐ Frame Out 0
☐ ☐ Print Trial ☐ Is Tracked ☐ Is Delivered

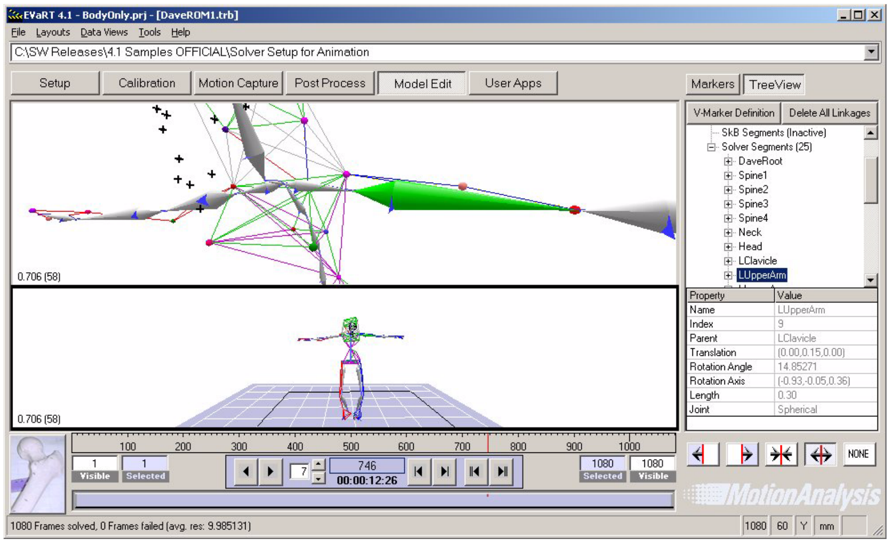
Chapter 13 Skeleton Types

Topic	Page
Overview	13-1
Skeleton Builder (SkB) Skeletons	13-2
Solver Type Skeletons	13-2
Which Skeleton Engine Should I Use?	13-3
EVaRT Skeleton Engine Selection	13-3
Skeleton Option Details	13-5
Exporting the Skeleton Data Into an HTR File	13-7
Multiple Characters and Multiple Skeletons	13-8

Overview

EVaRT supports two kinds of skeleton calculations, **Skeleton Builder** (SkB) skeletons and **Calcium Solver** type skeletons. Either kind is calculated in the **EVaRT** software and either can be calculated from live camera data, simulated Real Time with VC files, or from XYZ data in Post Processing. Both the marker data and the skeleton data are available to the **Talon** streaming plugins, such as the Maya and Kaydara Talon streaming plugins. The user can write their own plugin with the **Talon SDK** (Software Development Kit) available from Motion Analysis.

Figure 13-1. Calcium Solver Integrated with EVaRT



EVaRT 4.1 - BodyOnly.prj - [DaveROM1.trb]

C:\SW Releases\4.1 Samples OFFICIAL\Solver Setup for Animation

Property	Value
Name	LUpperArm
Index	9
Parent	LClavicle
Translation	(0.00,0.15,0.00)
Rotation Angle	14.85271
Rotation Axis	(-0.93,-0.05,0.36)
Length	0.30
Joint	Spherical

1080 Frames solved, 0 Frames failed (avg. res: 9.985131)

File Layouts Data Views Tools Help
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
Markers
TreeView
V-Marker Definition
Delete All Linkages
SkB Segments (Inactive)
Solver Segments (25)
DaveRoot
Spine1
Spine2
Spine3
Spine4
Neck
Head
LClavicle
LUpperArm
0.706 (58)
0.706 (58)
100 200 300 400 500 600 700 800 900 1000
1 Visible
1 Selected
7
746
00:00:12:26
1080 Selected
1080 Visible
NONE
MotionAnalysis
1080 60 Y mm

Skeleton Builder (SkB) Skeletons

Skeleton Builder (SkB) skeletons are relatively simple, direct and fast calculations of segments (bones) that are defined and calculated from one marker center to another. The markers can be real or virtual (calculated) and are typically from one virtual joint center to a second virtual joint center. A 3D local coordinate system is defined with 3 markers:

1. One marker defines the origin.
2. A second marker defines the bone (Y) axis.
3. The third marker defines the XY plane.

The advantage of the SkB type skeleton is that they compute very quickly and they represent the method of how most biomechanical models have been computed for many years. The disadvantage is seen when viewed on a skinned character in an animation package: The bones (segments) change length as a result of the calculation method. This is due primarily to the motion of the markers on the skin which changes from frame to frame. An animated character can be set up so that the character keeps a fixed length skeleton and the skeleton is driven only by the angles measured from the skeleton. This has the visually undesirable artifact that the character's feet will appear to slide on the floor and possibly raise above or protrude below the floor.

Solver Type Skeletons

Solver type skeletons are calculated quite differently than SkB skeletons. Solver uses the Global Optimization method of calculating the best fit of the marker data to the underlying fixed bone length skeleton. This technology was pioneered by Motion Analysis in 1990. The early version model setup was somewhat cumbersome and required physically measuring from a person's joint centers to the marker locations before the skeleton could be used. Now, the skeletons are defined and edited within the Calcium software interface within **EVaRT**. This provides a graphical way of either reading in an existing skeleton (or creating one) from an animation package such as Maya or 3DMAX. The typical way would be to create the character in the animation package and export the skeleton using an htr file using the MAC File IO plugins. The Global Optimization method is an iterative method of seeking the best fitting of the skeleton within the "marker cloud" of identified markers. The results are quite astounding: the animated characters motions derived from this method is very good. Final editing of the htr skeleton motion data can be done within the animation package or with a third party tool, such as Kaydara's Motionbuilder.

Which Skeleton Engine Should I Use?

SkB skeletons are good for most biomechanical applications and have been the norm there for many years. They are also used for animation customers who want fast “Pre-vis” tools for quick pre-visualizations of your characters motions.

For the final cut and the big screen presentations, where details matter and looks are everything, you will be glad to have your Calcium Solver skeletons under the skin of your final characters.

EVaRT Skeleton Engine Selection

The Engine Selection sets the method of calculating the (optional) skeleton model that can be calculated in **EVaRT** and later versions. There are two main skeleton engines available from Motion Analysis: Skeleton Builder, which was based on earlier SkB definitions, and Calcium Solver, based on Solver technologies. The **EVaRT** and later versions will run any skeleton engine that is previously defined without any additional licenses. To define or edit the skeleton definitions, you need additional licenses.

In the **EVaRT** and later releases, the skeleton model is saved with your marker set information in the project file. The **File > Load Marker Set** menu item will load the skeleton type from a PRJ file once it has been stored there.

Real Time and Simulated Real Time Skeletons

The Motion Capture panel has a Skeleton check box to ask if you want the Skeleton calculated with either mode: Connected (to cameras) or simulated real time (Disconnected-Use Raw Files). To see the skeleton, use the right-mouse click menu and select **Show Skeleton**.

Post Process Skeletons

Skeletons can also be calculated in the Post Processing panel from your current XYZ data that is visible in the 3D and XYZ data views.

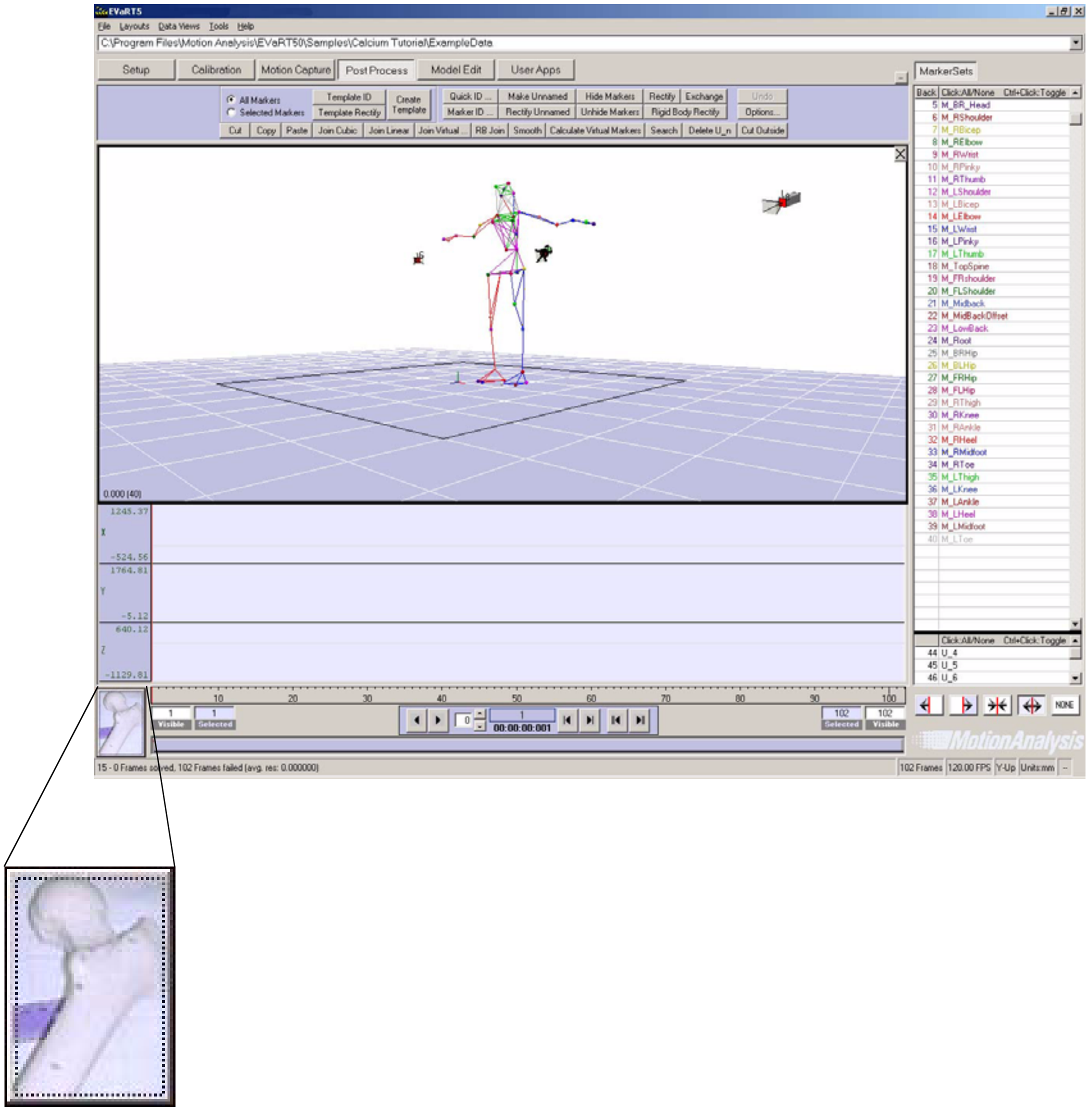
SkB Skeleton Builder skeletons

Skeleton Builder (SkB) skeletons are always calculated if the **SkB Skeleton Builder** option is selected. You can see the Skeleton by selecting **Show Skeleton** from the right mouse menu in the 3D data view. If you are using one of the streaming plugins, like the Maya Talon plugin or the Motionbuilder plugin, both the marker data and the calculated skeleton is available to drive your animated character from either the Real Time or Post Processing mode.

Calcium Solver Skeletons

If you have a Calcium Solver Skeleton defined in Post Processing, the Calculate Skeleton button (see Figure 13-2) appears on the lower left side of your Post Processing dashboard. You can first select a starting frame from the current time slider, then press the **Calculate Skeleton Bone** button which activates the Solver engine to do the Global Optimization method and solve for the skeleton beneath the marker cloud.

Figure 13-2. Calculate Skeleton Button


EVaRT5
File
Layouts
Data Views
Tools
Help
Setup
Calibration
Motion Capture
Post Process
Model Edit
User Apps
MarkerSets
● All Markers
○ Selected Markers
Template ID
Template Rectify
Create Template
Quick ID ...
Marker ID ...
Make Unnamed
Rectify Unnamed
Hide Markers
Unhide Markers
Rectify
Rigid Body Rectify
Exchange
Undo
Options...
Cut
Copy
Paste
Join Cubic
Join Linear
Join Virtual ...
RB Join
Smooth
Calculate Virtual Markers
Search
Delete U_n
Cut Outside
0.000 (40)
1245.37
X
-524.56
1764.81
Y
-5.12
640.12
Z
-1129.81
10
20
30
40
50
60
70
80
90
100
Visible
Selected
00:00:00:001
NONE
MotionAnalysis
102 Frames
120.00 FPS
Y-Up
Units:mm

C:\Program Files\Motion Analysis\EVaRT50\Samples\Calcium Tutorial\ExampleData

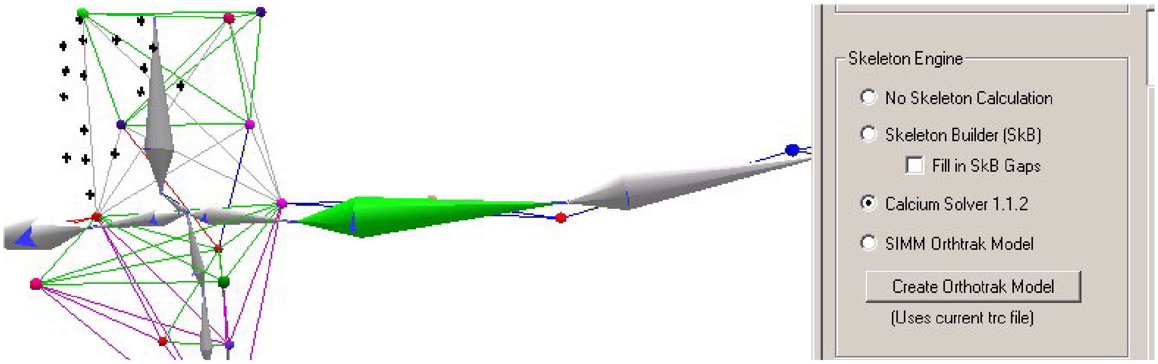
Back	Click:All/None Ctrl+Click:Toggle
5	M_BR_Head
6	M_RShoulder
7	M_RBicep
8	M_RElbow
9	M_RWrist
10	M_RPinky
11	M_RThumb
12	M_LShoulder
13	M_LBicep
14	M_LElbow
15	M_LWrist
16	M_LPinky
17	M_LThumb
18	M_TopSpine
19	M_FRshoulder
20	M_FLShoulder
21	M_Midback
22	M_MidBackOffset
23	M_LowBack
24	M_Root
25	M_BRHip
26	M_BLHip
27	M_FRHip
28	M_FLHip
29	M_RThigh
30	M_RKnee
31	M_RAnkle
32	M_RHeel
33	M_RMidfoot
34	M_RToe
35	M_LThigh
36	M_LKnee
37	M_LAnkle
38	M_LHeel
39	M_LMidfoot
40	M_LToe

	Click:All/None Ctrl+Click:Toggle
44	U_4
45	U_5
46	U_6

15 - 0 Frames solved, 102 Frames failed (avg. res: 0.000000)

This can take several seconds to minutes, depending on the length and complexity of the skeleton(s). If you are using one of the streaming Talon plugins, the skeleton data is available after the Bone Button calculations are finished. You can scrub back and forth in the Post Processing mode or press the **Play** button and both the marker data and the skeleton (htr type) data are available to the streaming Talon plugins (like Maya).

Figure 13-3. Skeleton Engine Setup



Skeleton Engine

○ No Skeleton Calculation

○ Skeleton Builder (SkB)

☐ Fill in SkB Gaps

● Calcium Solver 1.1.2

○ SIMM Orthtrak Model

Skeleton Option Details

No Skeleton Calculation

Even if a skeleton model is defined, the **EVaRT** software will not use it if this button is selected. This is the default value and the value for all project (prj) files saved previous to the **EVaRT** release.

Skeleton Builder (SkB) Engine

This calculates joint centers directly from real or virtual marker locations. Bone segments are defined from one marker to another, typically virtual markers that represent joint centers. The advantage to this method is the fast and direct calculations from markers to joint centers to bone segments. The disadvantage is primarily for high resolution animation use:, since the joint centers are calculated directly from real and virtual marker locations. Bone lengths will vary slightly from frame to frame due to marker-skin motion which can cause the animated character's skin to distort and not look as good as it expected.

Calcium Solver 1.1.2

This is a very different method of calculating the skeleton motion from marker locations. Typically, the skeleton is defined within one of the several animation packages and exported and saved in an HTR and a MOD (model) file. This skeleton is not allowed to change size to fit the motion data, but the Solver engine software uses a best fit Global Optimization of the marker data to conform to the rigid underlying skeleton. This results in the very best way of animating characters from mocap data, but to use it in **EVaRT**, you need to save a .mod file with the same name as your prj file. The **Calcium** software allows you to export a .mod file. The Solver Global Optimization method is resident in three of Motion Analysis Corporation's software products: **EVaRT, Calcium**, and the **SIMM** modeling package.

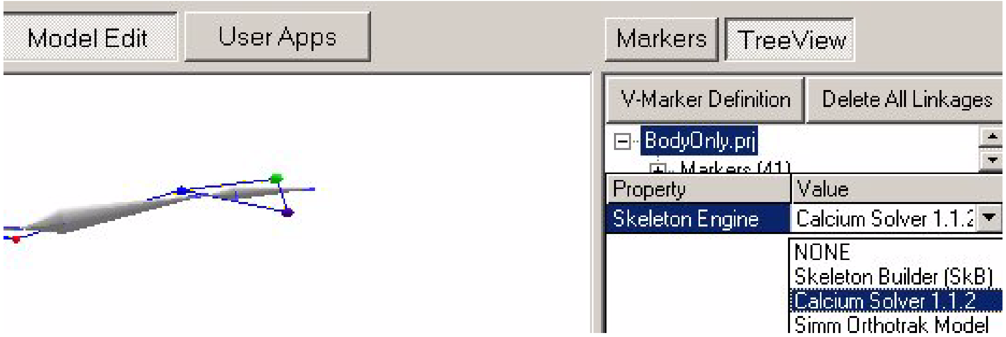
SIMM OrthoTrak Model

This uses the Solver engine with the same advantages as the **Calcium** Solver method above, but with a known and fixed marker set that was developed for biomechanics use. To use it, you must use some variation of the **OrthoTrak** marker set, which has several required markers (such as the Knee, Ankle, Hip and Shoulder markers) and many optional markers that will introduce more detail and more bone segments into the solution. The big advantage over the **Calcium** Solver model is that you do not need to create a MOD file, which means that you do not need to use or learn the **Calcium** software. The **EVaRT** software created an even more thorough JNT (joint) file when you press the **Create OrthoTrak Model** button on the **Setup > Misc** sub-panel. You do need to have the person standing in a neutral pose, typically with the arms out in a T-pose, feet slightly apart and thumbs forward. That is the current TRC file that needs to be loaded when you press the **Create OrthoTrak Model** button.

Model Edit Tree View

The Skeleton Engine type is also displayed and can be edited on the **Model Edit > Tree View** sub-panel when you select the prj name at the root of the Tree View. The Skeleton Engine type appears as the Value of the Skeleton Engine Property at the bottom of the Tree View sub-panel.

Figure 13-4. Model Edit Tree View



Property	Value
Skeleton Engine	Calcium Solver 1.1.

Exporting the Skeleton Data Into an HTR File

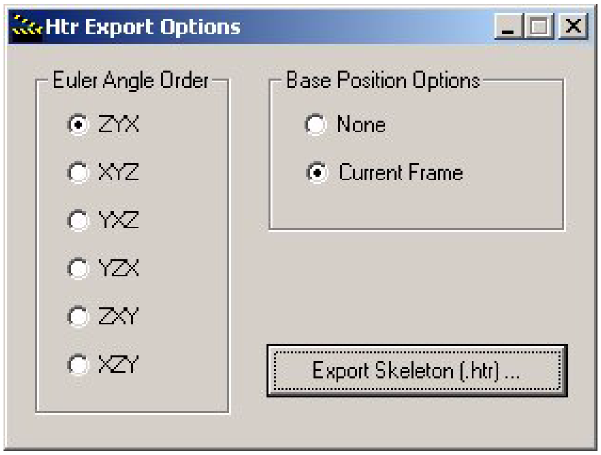
The **SkB** or Solver type skeleton data can be saved to an HTR (hierarchical translations and rotations) file after you calculate it and view it in **EVaRT**. Select the **File > Export HTR file...** menu item. This is for use with animation packages. You will then select the default top Euler Angle Order (ZYX) since that is how the plugins are built to receive the data.

The following are options on the Export HTR file menu:

Euler Angle Order

Use ZYX (which is the default) if you are going to import this with a Motion Analysis File IO plugin to the animation packages.Other Euler Angle orders will be decided by your local mathematicians. The numbers in the **EVaRT** software are stored internally in a certain way and exported to the HTR file according to the method above.

Figure 13-5. HTR Export Options



Htr Export Options

Euler Angle Order
● ZYX
○ XYZ
○ YXZ
○ YZX
○ ZXY
○ XZY

Base Position Options
○ None
● Current Frame

Base Position Options

Angles in the columns of HTR data are absolute angles according to the coordinate systems defined. This is typically used by biomechanics and research customers.

Current Frame

The absolute angles in the currently selected frame are written out in the file header of the HTR file. The angles in the columns are zero referenced to the angles in the file header. Use this method option if you are going to read the htr files into an animation package with the Motion Analysis File IO plugins.

Licensing Notes

SkB skeletons are defined and edited within the **EVaRT** software and require a separate license item, but they can be run and the skeletons data generated without additional licenses in **EVaRT** and later versions. There is separate documentation provided with the Skeleton Builder that shows how to set up and edit **SkB** skeletons.

Calcium Solver skeletons are imported or created in the **Calcium** software. **Calcium** software requires a separate license to edit or create the skeletons, but they too can be run and the skeleton data created from **EVaRT** or later versions without a separate license. **Calcium** also can create the HTR skeleton data using the same Solver engine as **EVaRT** and the **SIMM Motion Module.**

Multiple Characters and Multiple Skeletons

When you specify additional marker sets, the skeleton engine needs to be in each of the project files that you select. The skeleton type is stored in the project file. For previously stored project files, open up each of the project files separately, go to the **Setup > Misc** sub-panel, and specify the appropriate skeleton engine, then save out the project file. Load one of the project files, then in the **Motion Capture > Objects** sub-panel, specify the second project file as an “Additional Tracking Object". You should then be able to load a .vc file, and both skeletons should become solved.

Chapter 14 Sky Scripting Interface

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Overview	14-1
Graphical User Interface	14-2
The Functions	14-3
The Script	14-4
Script Examples	14-5
Installation Notes	14-7
Frequently Asked Questions	14-7

Overview

Sky is the name of the scripting interface for **EVaRT**. It uses the VB Script engine to provide the semantic structure of the language along with Visual Basic to provide the graphical user interface of the window pane. Sky is intended as a tool for users to encapsulate elements of repetitive tasks such as file processing, data editing and parameter setting. This tool is intended for users who have some general knowledge of scripting and programming.

Most of the Sky functions are direct, simple wrappers for the corresponding **EVaRT** calls. Some exceptions have to do with sending messages to **EVaRT** and in re-arranging arrays of data that get passed back and forth.

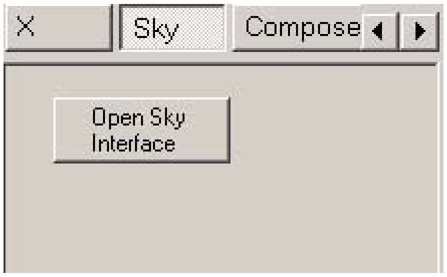
Sky does have an OCX file, which is named ScriptPlugin.ocx. When this file is loaded into the **EVaRT50\Plugins** directory, the Sky interface tab in the User Apps panels becomes active. The panel has one button that brings up the floating interface.

The Plugin Kit mostly consists of calling the **EVaRT.dll** functions, but it has some additional functions that must be filled as information to **EVaRT**. (e.g. name, type of plugin, etc.).

Graphical User Interface

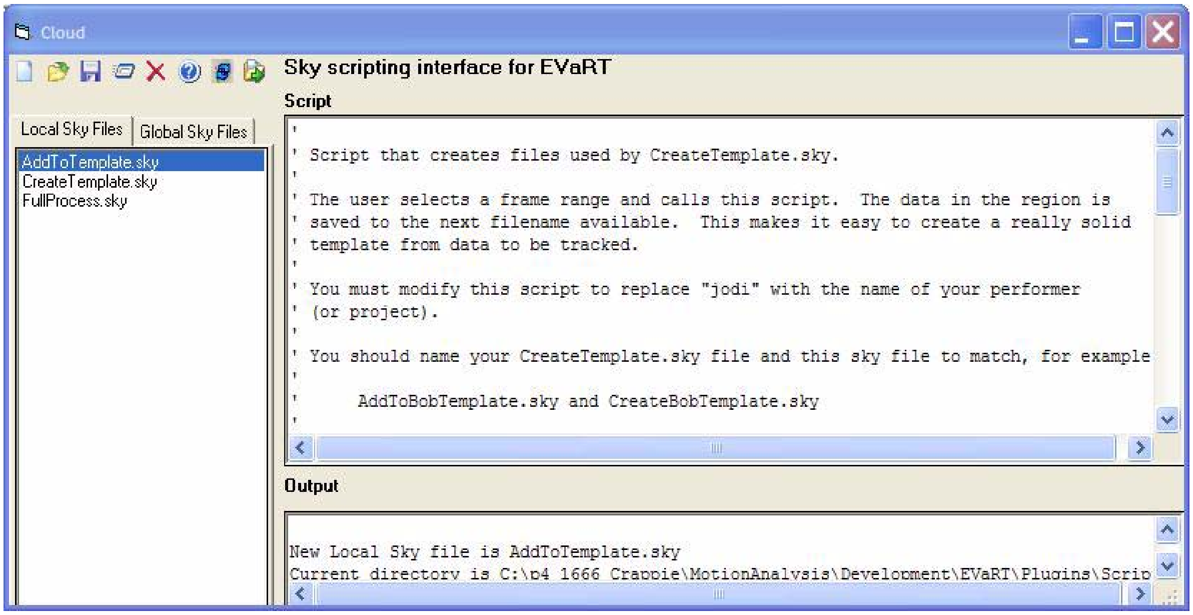
The user interface for Sky is found by going to the **User Apps > Sky** sub-panel.

Figure 14-1. Sky Sub-Panel


X
Sky
Compose
Open Sky Interface

Click on the **Open Sky Interface** button to bring up the floating window for the Sky interface.

Figure 14-2. Sky User Interface


Cloud
Sky scripting interface for EVaRT
Local Sky Files
Global Sky Files
AddToTemplate.sky
CreateTemplate.sky
FullProcess.sky
Script
Output

```
'
' Script that creates files used by CreateTemplate.sky.
'
' The user selects a frame range and calls this script.  The data in the region is
' saved to the next filename available.  This makes it easy to create a really solid
' template from data to be tracked.
'
' You must modify this script to replace "jodi" with the name of your performer
' (or project).
'
' You should name your CreateTemplate.sky file and this sky file to match, for example
'
'      AddToBobTemplate.sky and CreateBobTemplate.sky
'
```

```
New Local Sky file is AddToTemplate.sky
Current directory is C:\p4 1666 Crappie\MotionAnalysis\Development\EVaRT\Plugins\Scrip
```

Toolbar

- **New**—Clears the Script text editor and start editing a new script.

- **Open**—Brings up a file browser to find a sky file not in the current directory.
- **Save**—Saves the Script text to a new sky file.
- **Run**—Executes the text in the Script editor. This automatically saves the current script text to the current file.
- **Cancel**—Cancels the currently executing script. This works only if the script was written to use the swCancelled function.
- **Info**—Prints out basic information about Sky.
- **Refresh**—Causes Sky to refresh the Local Sky Files list (or the Global Sky Files list, which ever one is currently shown) by re-reading the appropriate directory.
- **Initialize**—Copies Sky files from the folder **MAC_DIR/UserFiles/SkyFiles/CopyPerProject** to the current working project directory. This makes it easy to initialize a new project with your favorite scripts. Will not overwrite existing scripts of the same name.

Local Sky Files

This contains a list of all the Sky files in the same directory as the current project. Load a file into the script interface by single-clicking on the filename. When you click a new file name, any changes you made to the currently loaded file are saved automatically. The currently loaded file name will continue to be highlighted for as long as that file is current.

Note: If you select the Local Sky Files tab when it is already selected then this will save out the current file. The current file is saved when you switch to the other tab.

Global Sky Files

This contains a list of all the Sky files in a common, global directory. This directory is a sub-folder of the folder pointed to by the environment variable MAC_DIR Load a file into the script interface by single-clicking on the filename. When you click a new file name, any changes you made to the currently loaded file are saved automatically. The currently loaded file name will continue to be highlighted for as long as that file is current.

Note: If you select the Global Sky Files tab when it is already selected then this will save out the current file.The current file is saved when you switch to the other tab.

Script

The currently loaded script. This is what will be run when the Run button is selected.

Output

Displays output from the scripting engine. Error messages from the scripting engine will be displayed as well as any text messages from the script. The output text area is refreshed when a new file is loaded.

The Functions

The scripting functions (for the most part) in Sky are simple wrappers for functions found in the **EVaRT** dll. Any call you make is immediately passed on to the corresponding core function in **EVaRT**. These are the same functions that the **EVaRT** GUI uses at runtime so (again, for the most part) you can do just about anything through the scripting interface that **EVaRT** does interactively.

All the script functions have the same name as the corresponding dll function call except a "sw" has been added to the beginning ("sw" stands for "Sky Writing").

A Functions list can be found in the file **Functions.html** located in the **C:\Program Files\Motion Analysis\EVaRT50\UserFiles\SkyFiles\SkyDocumentation_Mar23_05** directory.

The Script

The scripting language is VB Script. The only requirement for the script is that it has a Main() function in it, like so:

```
Sub Main
    ' commands go here
End Sub
```

Sky calls the script and executes the main function. You can create and use other subroutines and functions from Main.

Script Examples

Data files for all the script examples, along with copies of the scripts and the data they use, are found in the DataExamples subfolder. Note that some scripts might require a change in file paths to point to where you have placed this data on your computer system.

- **Resample.sky**—Invokes an external command line program to resample a TRC file (changes the frame rate).
- **MesssageTest.sky**—Logs messages to a file. How to delete a file. How to create a folder.
- **MsgBox.sky**—Example of using the built-in VB Script functions MsgBox and InputBox.
- **CreateTemplate.sky**—Create a template from a ROM (Range of Motion) track and then extend the template with a series of other TRB files.
- **Record.sky**—Load a VC file and record to a TRB file.
- **DeSpikeAll.sky**—Find and remove spikes from all markers in the tracks file.
- **DeSpikeSelected.sky**—Find and remove spikes from selected markers in the tracks file over the selected region.
- **SingleFrameDelete.sky**—Find and remove single frame trajectories.
- **VMJoinAll.sky**—Perform a VM Join (virtual marker join) on all markers.
- **FilterAll.sky**—Filter all markers over all frames.
- **FullProcess.sky**—A complete data example showing a master script calling a sequence of other scripts to perform a complete track, clean, and gap fill of a long motion with many occluded markers.
- **Trb2HTR.sky**—load a sequence of tracks file and create a set of corresponding HTR files.
- **Trb2Trc.sky**—Export a sequence of Ascii tracks files from binary tracks file.
- **FindAutoIDFrame.sky**—Find a valid for an AutoID and do the AutoID (Template ID)
- **AutoIDAllFrames.sky**—Perform an Auto ID on all frames.
- **RecordFive.sky**—Record five different files from the same VC capture file that had five performers.
- **ProcessBill.sky**—Process one of the five people in the ProcessFive.sky example.
- **ProcessFive.sky**—Process a data file containing five performers.
- **FindMaxSpeed.sky**—Find a value for the Max Speed tracking parameter by find the largest distance a marker moves in one frame.

A complete listing of these Sky example files is located in the **Examples.html** file in the Sky folder of the **EVaRT** release CD.

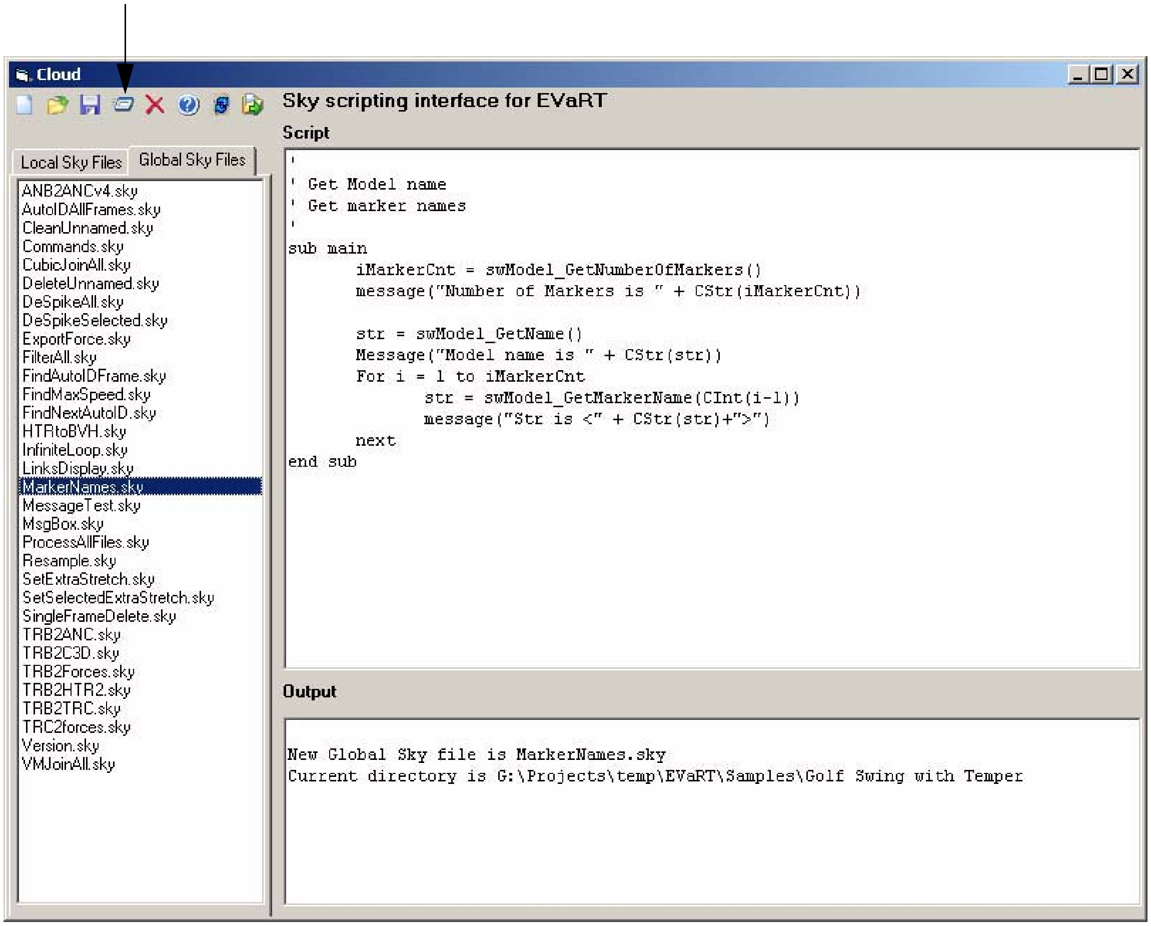
Example of Loading a Sky File

This example shows a simple demonstration of a Sky file and what it can typically do for a data set. This example will list all the marker names used in the current project file.

1. In the Sky sub-panel, click on the **Open Sky Interface** button.
2. In the Global Sky Files tab, select the **MarkerNames.sky** file from the listing.
3. Click on the **Run Script** button (see Figure 14-3). You will notice that the script runs, but there are no markers listed (as you have no project file loaded).

Figure 14-3. Sky Interface - Run Script Button

Run Script Button


Cloud
Sky scripting interface for EVaRT
Local Sky Files
Global Sky Files
ANB2ANCv4.sky
AutoIDAllFrames.sky
CleanUnnamed.sky
Commands.sky
CubicJoinAll.sky
DeleteUnnamed.sky
DeSpikeAll.sky
DeSpikeSelected.sky
ExportForce.sky
FilterAll.sky
FindAutoIDFrame.sky
FindMaxSpeed.sky
FindNextAutoID.sky
HTRtoBVH.sky
InfiniteLoop.sky
LinksDisplay.sky
MarkerNames.sky
MessageTest.sky
MsgBox.sky
ProcessAllFiles.sky
Resample.sky
SetExtraStretch.sky
SetSelectedExtraStretch.sky
SingleFrameDelete.sky
TRB2ANC.sky
TRB2C3D.sky
TRB2Forces.sky
TRB2HTR2.sky
TRB2TRC.sky
TRC2forces.sky
Version.sky
VMJoinAll.sky
Script
Output

```
'
' Get Model name
' Get marker names
'
sub main
        iMarkerCnt = swModel_GetNumberOfMarkers()
        message("Number of Markers is " + CStr(iMarkerCnt))

        str = swModel_GetName()
        Message("Model name is " + CStr(str))
        For i = 1 to iMarkerCnt
                str = swModel_GetMarkerName(CInt(i-1))
                message("Str is <" + CStr(str)+">")
        next
end sub
```

```
New Global Sky file is MarkerNames.sky
Current directory is G:\Projects\temp\EVaRT\Samples\Golf Swing with Temper
```

4. Load a project file and then a tracks file.
5. Click on the **Run Script** button again.
6. At the bottom of the Sky interface, you will see the model name and the markers of the project file listed.

Installation Notes

Sky Writer is automatically installed into **EVaRT**. If you are using an earlier version of **EVaRT** and it is not installed, you can utilize the information in this section.

Installing ScriptPlugin.ocx

The file "ScriptPlugin.ocx" is the Sky plugin file for **EVaRT**. It needs to be copied to the "Plugins" folder where **EVaRT** is installed.

Installing msscript.ocx

The file **msscript.ocx** is a Windows file that must be registered with Windows to activate the use of the VB Script engine. To install it (which must be done only once) copy the **msscript.ocx** file to a permanent folder location, such as the Motion Analysis folder (usually **C:\Program Files\Motion Analysis**) and then execute the following Windows sequence:

1. Under the Start menu in Windows, select **Run**.
2. Execute the following (assuming the **msscript.ocx** was copied to the location listed above):
   regsvr32 "C:\Program Files\Motion Analysis\msscript.ocx"

   This can also be done from the command prompt.

Installing Example Sky Files and Data

In order for the example scripts associated with the example project data to work, certain Sky scripts need to be copied to the Global Sky Files location. The contents of the SkyFiles folder in the Example Data directory should be copied to the SkyFiles folder that resides in the folder pointed to by the MAC_DIR environment variable. If the folder doesn't exist, you need to create one (when Sky starts up it will create the folder if it doesn't exist).

Execution of Command Line Programs

There are Sky commands (swTrcResample, swExecuteProcess) that allow for the invocation of command line applications. The swTrcResample command requires that there be a bin directory right below the Motion Analysis root directory (pointed to by the MAC_DIR environment variable). The application file **TrcResample.exe** must be placed in the bin folder for the swTrcResample command to work. TrcResample is part of the mocap toolkit available from the FTP site. Contact Motion Analysis Customer Support for information on getting the toolkit (support@motionanalysis.com).

Frequently Asked Questions

1. *When I press "Run" it doesn't run the current script, it appears to run another script or it gives me an error at line 0.*

   This is likely due to not having a "Sub Main" before any actual commands (and a matching "Sub End" at the end of the script). The scripter requires a Main routine to call.

2. *I get a "Script Syntax Error" when I try to call a function.*

If you're certain that you've spelled the function's name correctly then it's likely the specific function hasn't been implemented yet. Check with Motion Analysis' Customer support.

Also be sure that all the function arguments are spelled correctly and are the correct type. This is especially important for String arguments. You might have to force the correct type by putting CStr() around the argument.

3. *Is there a "Listener" that can track my interactive work with* **EVaRT** *and list out the corresponding Sky commands to perform the same task?*

   No, unfortunately not at this time. Since Sky was developed as a plugin to **EVaRT** it isn't possible to incorporate this type of feature.

4. *When do my Sky file changes get saved?*

   At every opportunity to do so the Sky interface will automatically save out the contents of the Input Text window to the currently selected file. Some examples: when the file list is changed from Local to Global; when you run the script; when you load another script and when you close the Sky window. The only times when a script isn't saved is when **EVaRT** is closed down without first closing the Sky window or if **EVaRT** crashes.

Chapter 15

QuickDB

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Usage Notes	15-2
QuickDB Terminology	15-3
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Overview

QuickDB is an integrated database tool for **EVaRT** that allows the user to easily track all **EVaRT** project information. Microsoft Access databases are used to tabulate information about your projects (a copy of Microsoft Access is not required to take advantage of this tool). A master database keeps a list of all the individual projects you make. Each individual project (called a "session list") keeps track of all the data associated with a specific project directory (project files, VC files, tracks files, etc...). It is fast and easy to create a session list of any data you already have. QuickDB will scan your project directory for the data you have already collected and will create the session database for you.

QuickDB is all of the following:

- Is very handy for keeping track of all your projects, you can scan for and then load project data with ease.
- Will record your trials as you collect data.
- Contains tracking information about a trial's Post Process status.
- Allow's multiple user access to shared session databases.
- Makes it easy to share databases with other users.
- Allows the creation of capture lists ahead of time so that capture names can be loaded from QuickDB while recording a session.
- Is an SQL database that can be used to generate reports on project status.

Installation Instructions

The main projects database file is called **MasterProjectsList.mdb**. This file must be stored in the **Userfiles\Databases** folder under where the main **EVaRT** directory is found. For a standard installation, this will be **C:\Program Files\Motion Analysis\EVaRT47\Userfiles\Databases\MasterProjectsList.mdb.**

Be sure to copy the same databases folder to this location. Another required database file is **SessionTemplate.mdb**. This is also found in the **Userfiles\Databases** folder. This is a blank-session database that is used to make new databases and add them to the **MasterProjectsList.mdb** file.

Copy the QuickDB.ocx file to the plugins folder under the specific EVaRT installation. For example, this might be **C:\Program Files\Motion Analysis\EVaRT47\EVaRT4.7.5\plugins\QuickDB.ocx**.

If you do not have development tools (Visual Studio 6 or later) then you will have to install some system OCX files that are required by QuickDB. The installer for this is found in the **Package** directory and is called **Setup.exe**. Run this installer to install and register the Windows ocx files for handling database interaction. Again, Microsoft Access is not required to be installed to run QuickDB.

Quick-Start Steps

1. Open the QuickDB interface found in the **User Apps** panel.
2. Select the **New** button on the right to create a new database.
3. Click on the **Scan Folder...** button and then select a folder full of trials that you have already created.
4. Select a files from the TrialName list
5. Select **Load into EVaRT**.
6. Select **Sync with EVaRT**.

You should now have a new session database and the trial that you selected is now completely loaded into **EVaRT** (project file, VC file and any tracks files). Furthermore, all the information about this trial is saved in the new session database that you just created.

Usage Notes

All motion capture data files are assumed to be of the form "Base##.ext". Where "ext" is the extension type ("vc1", "trb" or "trc"). The ## portion refers to the trial number that is automatically appended to the base name of the trial. The QuickDB interface will not work with files that do not have this form.

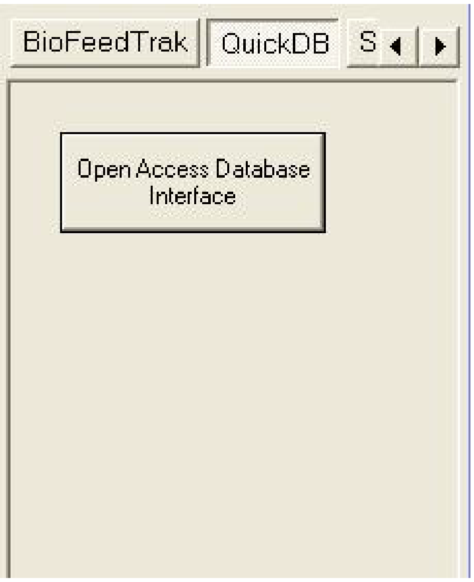
QuickDB Terminology

The following are general phrase definitions associated with QuickDB.

Master Project List	This is the master list of projects from the **MasterProjectList.mdb** file.
Session List	This is the database file which contains the list of trials. Each item in the Master Project List refers to one of these.
Trial	One motion capture data set from **EVaRT**. Sometimes called a "shot". This is one set of VC files and the corresponding TRB or TRC file.
Shot	Same meaning as "Trial".
Record	In database terminology, this is a line of data in the database table.

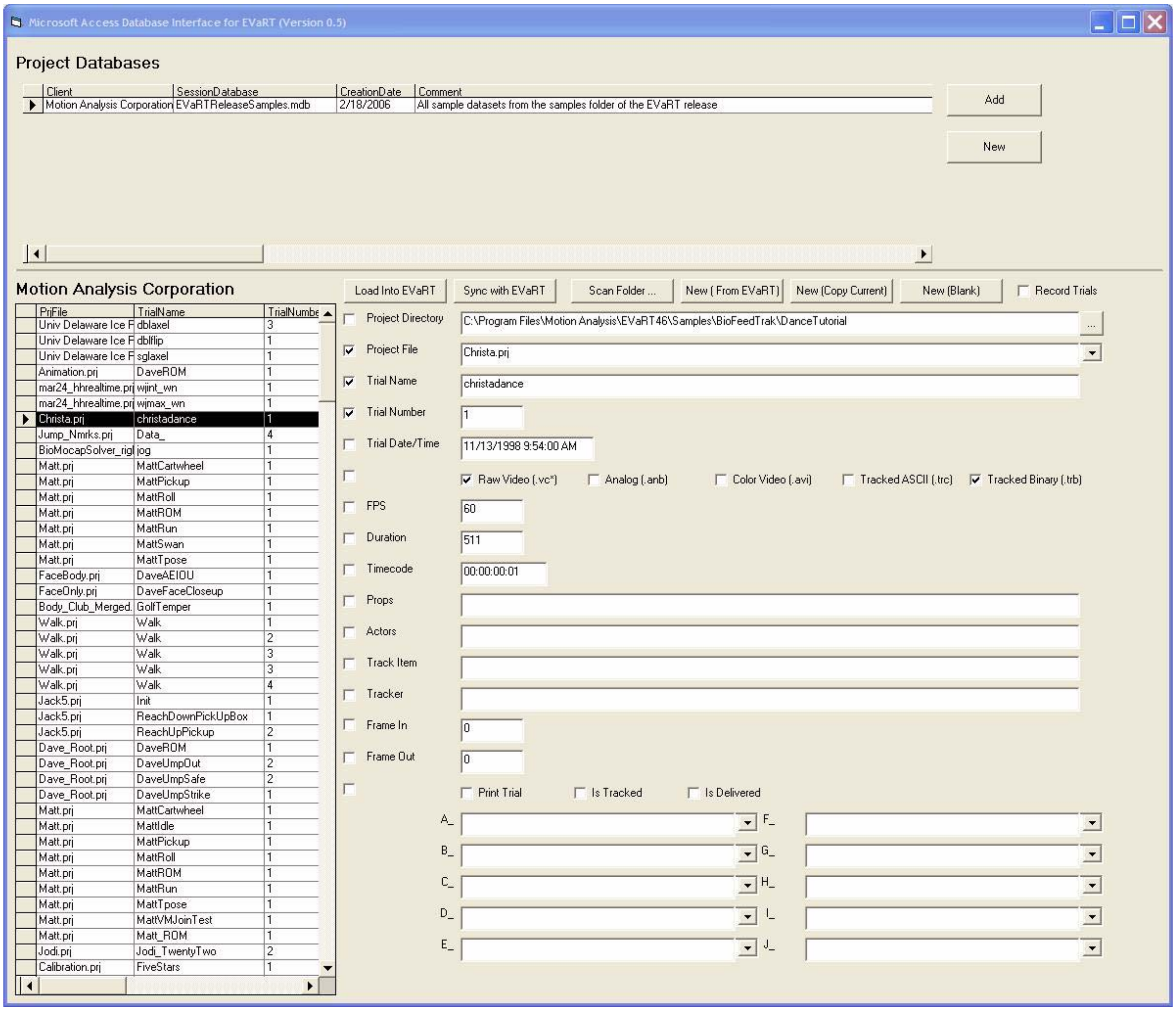
User Interface

Figure 15-1. User Apps > QuickDB Panel



Bring up the main QuickDB interface by selecting the **Open Access Database Interface** button in the User Apps > QuickDB panel.

Figure 15-2. QuickDB Interface



Client	SessionDatabase	CreationDate	Comment
Motion Analysis Corporation	EVaRTReleaseSamples.mdb	2/18/2006	All sample datasets from the samples folder of the EVaRT release

PrjFile	TrialName	TrialNumbe
Univ Delaware Ice F	dblaxel	3
Univ Delaware Ice F	dblflip	1
Univ Delaware Ice F	sglaxel	1
Animation.prj	DaveROM	1
mar24_hhrealtime.prj	wjint_wn	1
mar24_hhrealtime.prj	wjmax_wn	1
Christa.prj	christadance	1
Jump_Nmrks.prj	Data_	4
BioMocapSolver_rigl	jog	1
Matt.prj	MattCartwheel	1
Matt.prj	MattPickup	1
Matt.prj	MattRoll	1
Matt.prj	MattROM	1
Matt.prj	MattRun	1
Matt.prj	MattSwan	1
Matt.prj	MattTpose	1
FaceBody.prj	DaveAEIOU	1
FaceOnly.prj	DaveFaceCloseup	1
Body_Club_Merged.	GolfTemper	1
Walk.prj	Walk	1
Walk.prj	Walk	2
Walk.prj	Walk	3
Walk.prj	Walk	3
Walk.prj	Walk	4
Jack5.prj	Init	1
Jack5.prj	ReachDownPickUpBox	1
Jack5.prj	ReachUpPickup	2
Dave_Root.prj	DaveROM	1
Dave_Root.prj	DaveUmpOut	2
Dave_Root.prj	DaveUmpSafe	2
Dave_Root.prj	DaveUmpStrike	1
Matt.prj	MattCartwheel	1
Matt.prj	MattIdle	1
Matt.prj	MattPickup	1
Matt.prj	MattRoll	1
Matt.prj	MattROM	1
Matt.prj	MattRun	1
Matt.prj	MattTpose	1
Matt.prj	MattVMJoinTest	1
Matt.prj	Matt_ROM	1
Jodi.prj	Jodi_TwentyTwo	2
Calibration.prj	FiveStars	1

☐ Project Directory: C:\Program Files\Motion Analysis\EVaRT46\Samples\BioFeedTrak\DanceTutorial
☑ Project File: Christa.prj
☑ Trial Name: christadance
☑ Trial Number: 1
☐ Trial Date/Time: 11/13/1998 9:54:00 AM
☐ ☑ Raw Video (.vc*) ☐ Analog (.anb) ☐ Color Video (.avi) ☐ Tracked ASCII (.trc) ☑ Tracked Binary (.trb)
☐ FPS: 60
☐ Duration: 511
☐ Timecode: 00:00:00:01
☐ Props:
☐ Actors:
☐ Track Item:
☐ Tracker:
☐ Frame In: 0
☐ Frame Out: 0
☐ ☐ Print Trial ☐ Is Tracked ☐ Is Delivered

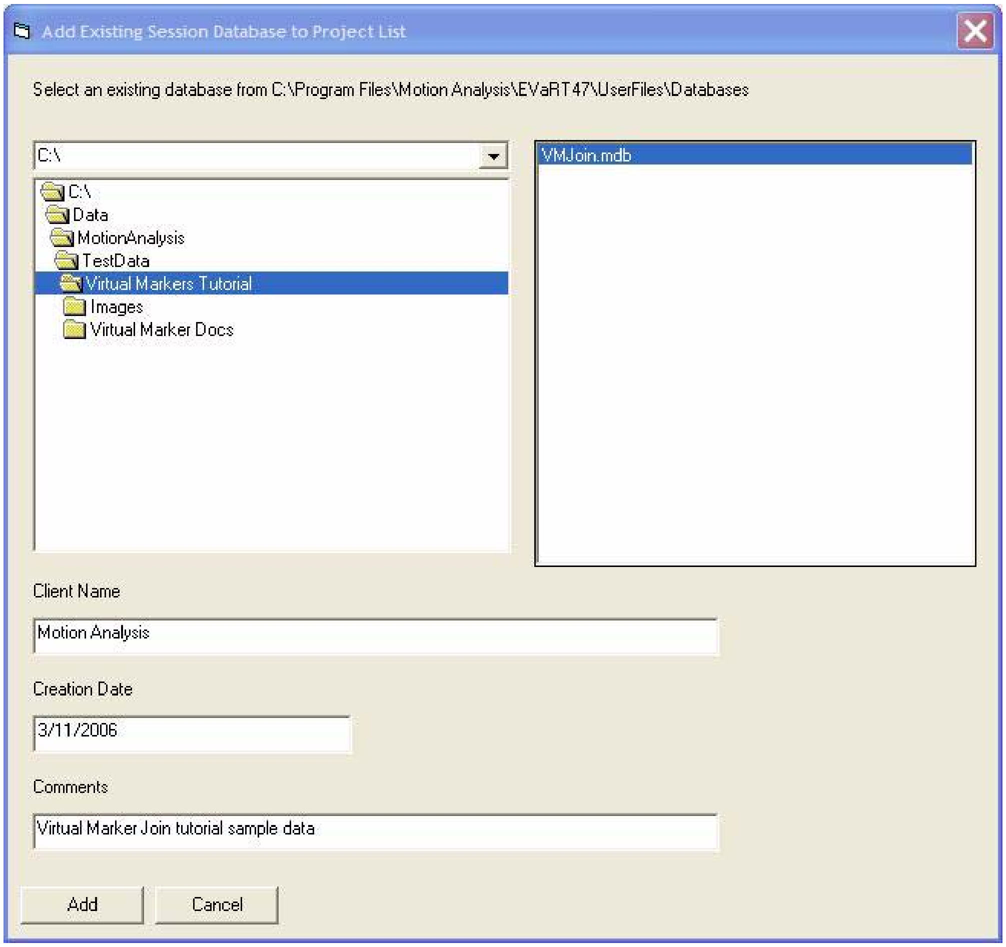
Project Databases

This is the list of databases from the **MasterProjectsList.mdb** file. Select the session you wish to view by selecting any of the fields in the projects list. You can edit any of the fields by selecting them and typing in your changes. These changes take effect immediately and are stored in the database as soon as you make the change. To delete any item from the list, select the whole row and press the **Delete** key on your keyboard. This will remove the entry from the master list but it does NOT delete the corresponding session database file. This file is left alone.

When you start up the QuickDB interface, it will automatically move to the end of the projects list to put you on the most recently created entry.

Add

Figure 15-3. Add DB Panel


Add Existing Session Database to Project List
C:\
C:\
Data
MotionAnalysis
TestData
Virtual Markers Tutorial
Images
Virtual Marker Docs
Add
Cancel

Select an existing database from C:\Program Files\Motion Analysis\EVaRT47\UserFiles\Databases

VMJoin.mdb

Client Name: Motion Analysis

Creation Date: 3/11/2006

Comments: Virtual Marker Join tutorial sample data

This is to add a session database entry to the Master Project List for an existing session database. For example, if another **EVaRT** user has created a list for you to use, you can copy this .mdb file to a new location or you can add a reference to the original file created by the other user.

Folder/File Selection

Select the database file you wish to add by browsing to the correct folder and then selecting the .mdb file.

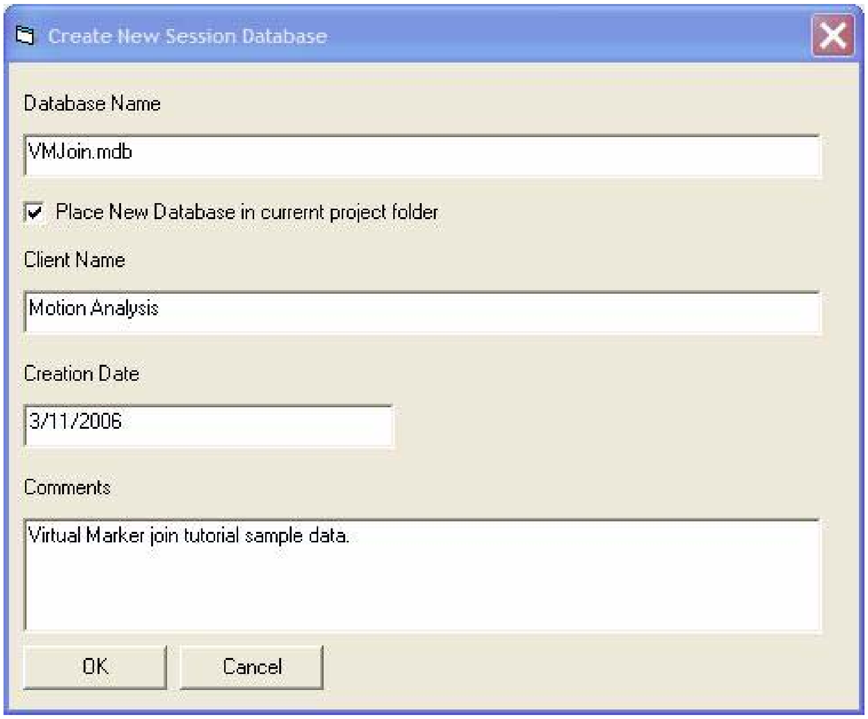
Client Name

This is a string field that allows you specify the client for the data. It is really nothing more than another comment field, but since this field is displayed first in the Project Databases list, it should be something that is unique and descriptive.

Creation Date	The creation date of the mdb file. The current date is entered by default, but you can change it if necessary.
Comments	A comment field limited to 255 characters. This is used to help you remember what the session database contains.
Add	When all the above fields and sections are made, this button is enabled. When pressed, a new record is added to the Project Databases list (which is saved in the **MasterProjectsList.mdb** file).
Cancel	Cancel the Add operation at any time. You can also close the dialog window and cancel the operation using the Windows Close button in the upper right corner of the dialog.

New

Figure 15-4. New DB Panel



Create New Session Database

Database Name
VMJoin.mdb

☑ Place New Database in currernt project folder

Client Name
Motion Analysis

Creation Date
3/11/2006

Comments
Virtual Marker join tutorial sample data.

This creates a new session database and places the new .mdb file in a location specified by the user. The default location is to use the **Userfiles\Databases** folder but the location of the database can be anywhere. An option to make the database in the same folder as the current project is provided. This makes the database easily relocated along with all the project and mocap data. This operation works by copying an existing mdb file (**SessionTemplate.mdb**) from the **Userfiles\Databases** folder to the name of the new database. If the **SessionTemplate.mdb** file doesn't exist, then the operation will fail.

Database Name

The name of the new database to be created.

Place New Database In Current Project Folder

A flag indicating that instead of placing the new database in the **Userfiles\Databases** folder, the new database should be located in the current project directory.

Client Name

This is a string field that allows you specify the client for the data. It is really nothing more than another comment field, but since this field is displayed first in the Project Databases list, it should be something that is unique and descriptive.

Creation Date

The creation date of the mdb file. The current date is entered by default, but you can change it if necessary

Comments

A comment field limited to 255 characters. A reminder to help you remember what the session database contains.

Ok

When all the above fields and sections are made this button is enabled. When pressed, a new record is added to the Project Databases list (which is saved in the MasterProjectsList.mdb file) and a new database file is created for the session database.

Cancel

Cancel the new operation at any time. You can also close the dialog window and cancel the operation selecting the **Close** button in the upper right corner of the dialog.

Trial List

The trial list contains the names of all the trials in the session database. All the values for the currently selected item are shown in the fields to the right of the Trial List. Any changes take effect immediately and are immediately stored in the session database.

Scan Folder

This brings up a dialog that allows the user to specify a folder to be scanned for pre-existing motion capture data. The folder can be scanned for one of VC, TRB or TRC files. One project file must be specified for all trials to be created (there isn't any way to determine which project should be associated with each trial by examining the trial data). The user is expected to go back later and update the project file for each trial. When searching for a folder to scan, the dialog will look for files of each of the types and will disable the corresponding option if files of that type are not found.

A new trial will be created for each motion capture file found. The file names must adhere to the form described in the Usage Notes section. This is to allow the scanner to find the trial number for each file.

You can scan as many folders as many times as you wish to add items to the session database. There is no requirement that all the trials be located in the same folder.

New (From EVaRT)

This creates a new trial and adds it to the session database. Fields are filled in by inspecting **EVaRT** for information. This is just like selecting **New** (Blank) and then selecting **Sync with EVaRT**.

New (Copy Current)

This creates a new trial and adds it to the session database. All the fields are copied from the currently selected trial. This is useful for creating a lot of trials to be used later in a motion capture session (see Load Into EVaRT for more information).

New (Blank)

This creates a new trial and adds it to the database. All the fields are made to be blank.

Load Into EVaRT

This loads the information from the currently selected trial into **EVaRT.** The project file is loaded first. Then, if the VC file and any of the tracks files exists, they are loaded into the Post Process mode. If you have made changes to the currently loaded data, then this will be lost with no ability to recover.

If **EVaRT** is currently streaming live data (or in Record mode from a VC file) when you select this button, a warning message will be displayed indicating that no data was loaded.

If **EVaRT** is currently connected to cameras when you select this button, then ONLY the trial name, trial number, and any of the MTO projects will be updated in the Output panel of **EVaRT**. This is so that the connection to the cameras is not interrupted (as they would be if the project were loaded) and the trial list now becomes a template for a capture session.

Note: QuickDB is not currently able to notify **EVaRT** that the Trial Name and Trial Numbers have changed. If you select a panel other than the Output panel and then back to the Output panel you will see that the names have changed. Any subsequent records will go to the name specified by QuickDB even if you do not refresh the Output panel.

Sync with EVaRT

This inspects settings in **EVaRT** and updates the current record to match. This is a handy way of having **EVaRT** fill in the FPS, Duration and Timecode fields (only if a VC file has been loaded will this information be there). A useful trick after scanning a folder for trial names is to select each of the files, load into **EVaRT** and then select **Sync with EVaRT**. This information is immediately used to update the session database.

Record Trials

When selected, QuickDB will listen for Start Record and End Record events from **EVaRT** and will create a new Trial Record for each. The name of the trial will be taken from the Name field in the Settings area of the **Motion Capture > Output** panel.

Trial Fields

These are all the fields to the right of the Trial List. If you modify these values then they will have immediate effect. The check boxes to the left of the fields indicate which fields are to be displayed in the trials list.

Project Directory	This is the directory where all the project and motion capture data is contained. A special name of "." indicates that the project directory is the same folder as the location of the session database.
Project File	The project file associated with the main markerset.
Trial Name	The name of the trial.
Trial Number	The number of the trial.
Trial Date/Time	The time when the trial was captured. This is generally taken from the time stamp put on the file by Windows.
File Types	The types of files that exist for the trial. This is also used to indicate what kind of files are to be loaded into **EVaRT**. So it might be possible that a TRC files exists, but if it is left unchecked then it will not be loaded into **EVaRT** when the **Load Into EVaRT** button is selected.
FPS	Frames Per Second—This information is provided by **EVaRT** to QuickDB when **Sync With EVaRT** is selected.
Duration	The length of the trial in frames. This information is provided by **EVaRT** to QuickDB when **Sync With EVaRT** is selected.
Timecode	The Timecode value of the first frame of the trial. This information is provided by **EVaRT** to QuickDB when **Sync With EVaRT** is selected.
Props	A comment field used to indicate what props were present during the capture of the trial.
Actors	A comment field used to indicate what actors were present during the capture of the trial.
Track Item	The specific item (associated with a particular markerset) to be tracked and delivered by the user.
Tracker	The person responsible for tracking the data.
Frame In	The starting frame of the data to be delivered. Timecode is not used here because it isn't specific enough (more than one frame of data might fall on the same Timecode value).
Frame Out	The ending frame of the data to be delivered. Timecode is not used here because it isn't specific enough (more than one frame of data might fall on the same Timecode value).

Tracking Status	The current status of the trial.
Multiple Tracking Objects	Markerset names that are used to fill in the Additional Tracking Objects fields of the **Motion Capture > Objects** panel.

Frequently Asked Questions

I have pressed **Load Into EVaRT** *but I get no response. What is happening?*

If **EVaRT** is currently connected to cameras, then very little in **EVaRT** will change except the Name and Trial Number fields of the Settings area in the **Motion Capture > Output** panel and the Additional Tracking Objects list.

Appendix A

System Hardware Interconnections

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Overview	A-1
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Overview

This chapter provides information and illustrations on how to set up the hardware to be used with **EVaRT**. It is broken up into sections for setting up the Eagle, Hawk, Falcon, Pulnix, and Cohu camera systems.

When using **EVaRT** in the Motion Analysis motion capture system, hardware connections are straight-forward. The connection of the cameras to the EagleHub1, EagleHub2, or EagleHub3 (Eagle and Hawk digital camera system) or the Midas box (Falcon, Pulnix, and Cohu) all have unique labeled connectors.

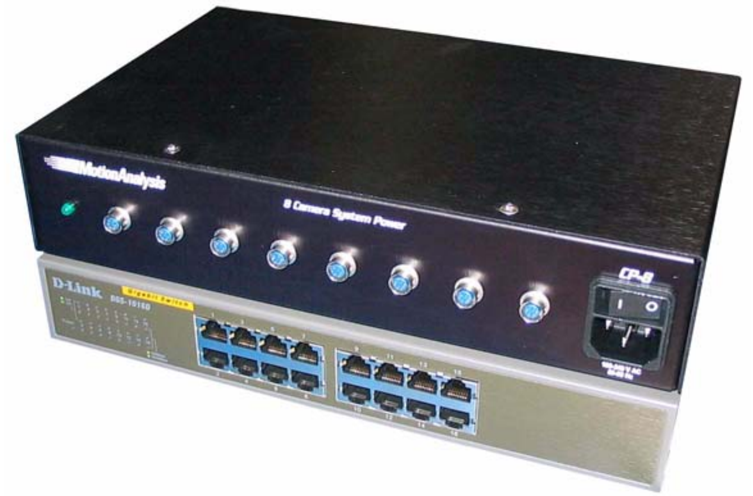
Note: Frame rate, shutter speeds, and ring light brightness for the Eagle and Hawk digital cameras are set using the **EVaRT** user interface.

Standard Eagle and Hawk System Configuration

Figure A-2 shows a standard **EVaRT** system set up for use with Eagle and Hawk digital cameras. It includes:

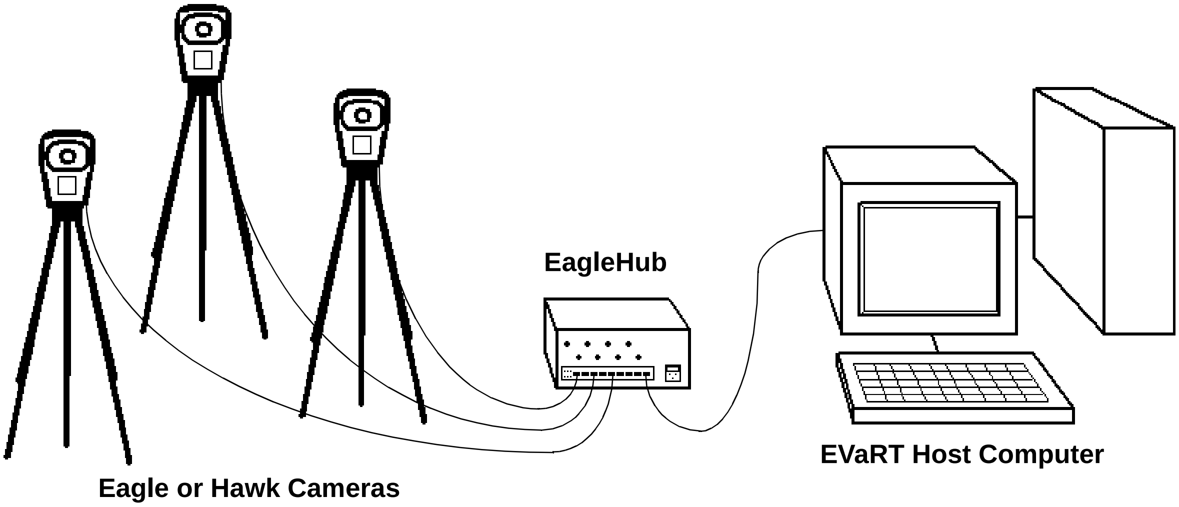
- a set of Eagle or Hawk digital cameras with Eagle network and power cables for each camera
- an EagleHub1 or EagleHub2 (1 for every 8 cameras) or EagleHub3 (1 for every 12 cameras)

Figure A-1. EagleHub Will Power 8 Eagle or Hawk Cameras with 17 Ethernet Connections


MotionAnalysis
8 Camera System Power
CP-8
D-Link

- a Tracking Computer (host) with monitor, keyboard, and mouse

Figure A-2. Standard Eagle or Hawk System Configuration


EagleHub
EVaRT Host Computer
Eagle or Hawk Cameras

For more detailed diagrams, please refer to Figures A-3 through A-10.

Power Consumption

The maximum power consumption you can expect for some typical Eagle and Hawk system configurations is shown in Table A-2. The actual power consumed depends on the video frame rate and the intensity of the ring lights and is usually less than that indicated.

For the most reliable system operation, it is recommended that all camera assemblies and computers be powered by an uninterrupted power supply (UPS). If you want to save your data when power is lost altogether, you will also need to power the VGA monitor from the UPS.

Table A-1. Power Consumption of Typical Eagle and Hawk Setups

	8 Cameras	12 Cameras	16 Cameras
EagleHubs with Cameras	265 W	400 W	530 W
21” SVGA Monitor	125 W	125 W	125 W
Dual Processor Computer	200 W	200 W	200 W
TOTAL	580 W	725 W	855 W

Basics of Ethernet Switches and Hubs

There is a difference between the older Ethernet hubs and the newer Ethernet switches, even though they look alike and are functionally similar. The difference is in the performance. Ethernet switches guarantee the full rated Ethernet bandwidth between all ports simultaneously, whereas the older Ethernet hubs share the bandwidth for all ports. We call the EagleHubs “hubs” to indicate that they are the center connection point for a block of cameras, but inside the EagleHub resides a switch. This performance difference is important and necessary for the Eagle and Hawk systems to function properly.

A 100 Mbps Ethernet switch works well for an Eagle or Hawk system with up to 16 cameras (low to moderate frame rate). For larger numbers of cameras (above 16), it is important to use the 1 Gbps Ethernet NIC (network interface card) inside the computer and the 1 Gbps Ethernet switch that collects and concentrates the camera traffic to the **EVaRT** Host computer.

Ethernet Tutorial and Troubleshooting Guide

There are two types of female Ethernet connections that use the same 8-pin Ethernet connector:

1. NIC-Type—The Ethernet connector that is found on the Network Interface Card on computers and on your Eagle or Hawk cameras.
2. Hub-Type—The standard Ethernet plug that is found on Ethernet switches and hubs.

There are two types of Ethernet cables:

1. Standard Ethernet patch cables
2. Ethernet cross-over cables

The standard patch cable is used to connect computers to Ethernet hubs and for connecting Eagle or Hawk cameras to the EagleHubs.

The Ethernet cross-over cable is used for connecting Ethernet hubs to other hubs, unless you use the Uplink port on either hub. In this case, you can use a standard patch cable. The cross-over cable would also be necessary if you were to bypass the Eagle hub and plug the Eagle or Hawk camera directly into your computer's NIC.

Troubleshooting

You can tell if you have a live Ethernet connection if the indicator light goes on when you plug the cable into the hub. This is also the best way to figure out whether or not your Ethernet cables are plugged in correctly. It will not damage anything if you plug in the wrong type of cable (patch or cross-over) into an Ethernet jack. For the indicator light to go on, there has to be a live Ethernet connection on both ends of the cables.

EagleHub3 Connections

When first setting up your Eagle or Hawk system, you will notice that the both the power and Ethernet connections for the cameras are integrated through the EagleHub3(s). Remember, the Eagle or Hawk system allows for 12 cameras per EagleHub3.

All camera power connectors are plugged into the power connectors of the EagleHub3. Order is not imperative as long as each power connector is close to an open Ethernet connector.

Mixing EagleHubs

There is no problem if you mix EagleHub1, EagleHub2, and EagleHub3 hubs in the same system. The EagleHub provides power and Ethernet connections for both Eagle and Hawk cameras and can be mixed.

1 Gbps Switch

A 1 Gbps Ethernet switch is required for best performance if you have more than 16 cameras and plan to use the higher camera speeds available.

Figure A-3. Standard 1-12 Eagle Camera, Single EagleHub3 Configuration

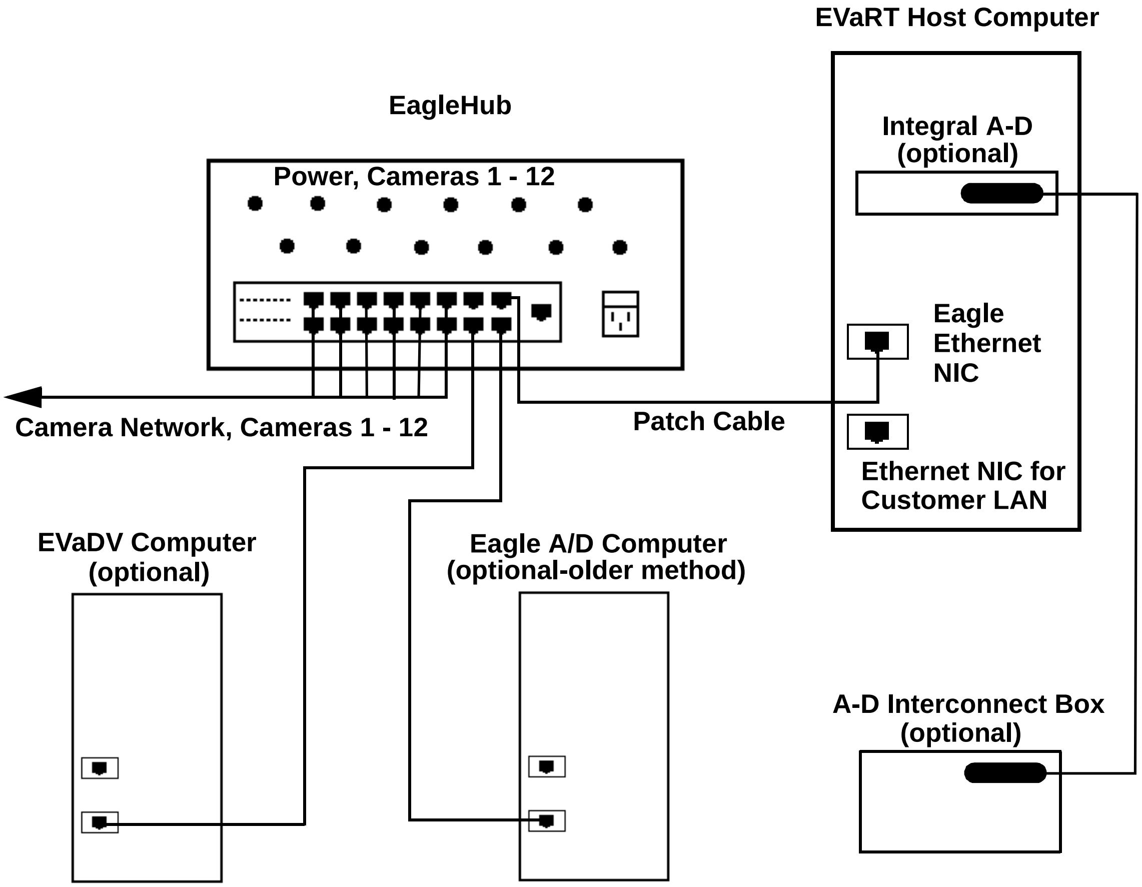
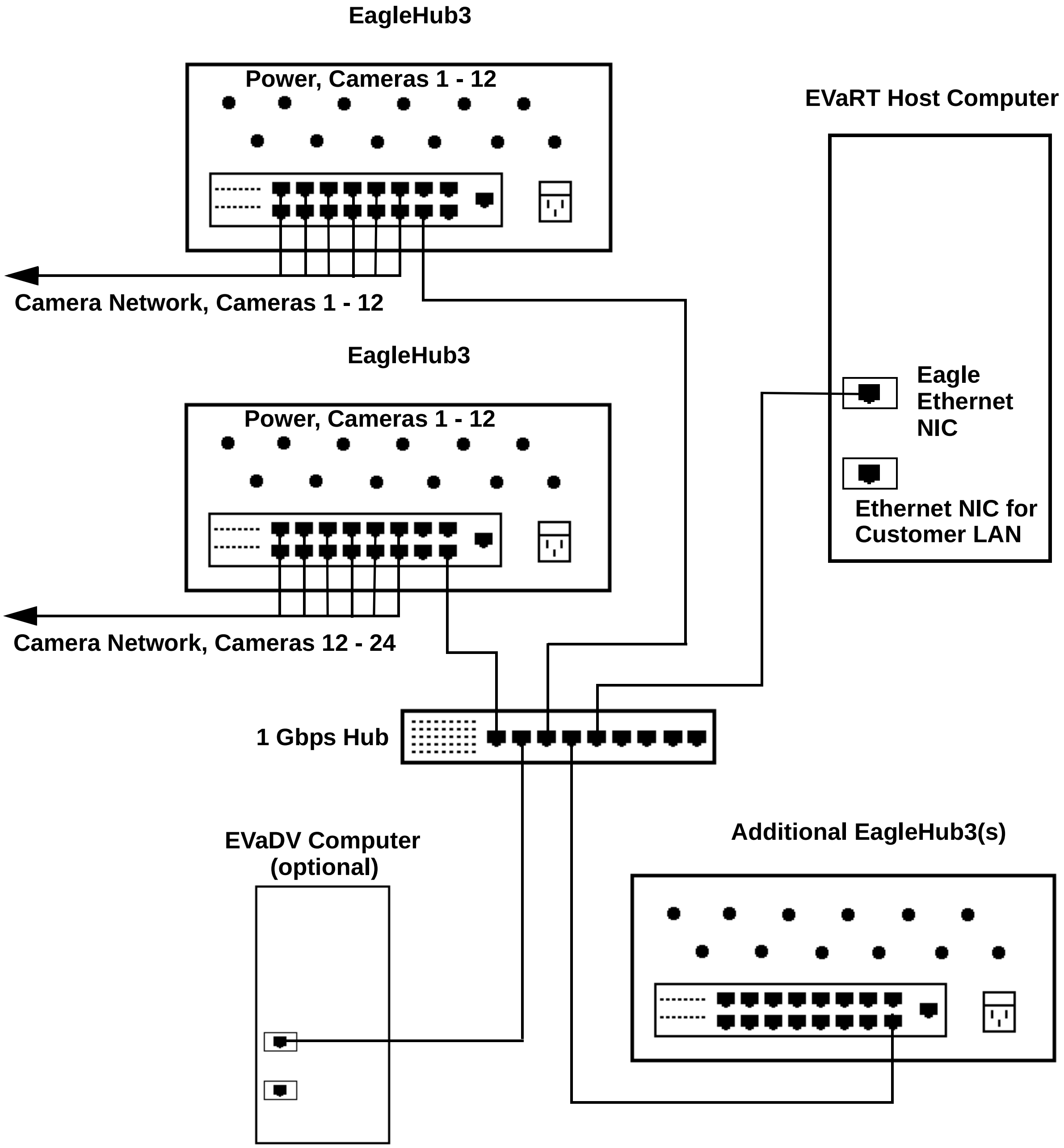

EVaRT Host Computer
EagleHub
Integral A-D
(optional)
Power, Cameras 1 - 12
Eagle
Ethernet
NIC
Camera Network, Cameras 1 - 12
Patch Cable
Ethernet NIC for
Customer LAN
EVaDV Computer
(optional)
Eagle A/D Computer
(optional-older method)
A-D Interconnect Box
(optional)

Figure A-4. Eagle or Hawk Camera, Multiple EagleHub3 Configuration (12+ cameras)


EagleHub3
Power, Cameras 1 - 12
Camera Network, Cameras 1 - 12
EagleHub3
Power, Cameras 1 - 12
Camera Network, Cameras 12 - 24
EVaRT Host Computer
Eagle Ethernet NIC
Ethernet NIC for Customer LAN
1 Gbps Hub
EVaDV Computer (optional)
Additional EagleHub3(s)

Note: The standard multi-EagleHub3 setup is designed for the hubs to be distributed around the motion capture volume. If you desire to have the EagleHubs in a central location, you may need to use different camera cable lengths than those originally shipped with your system.

EagleHub1 and EagleHub2 Connections

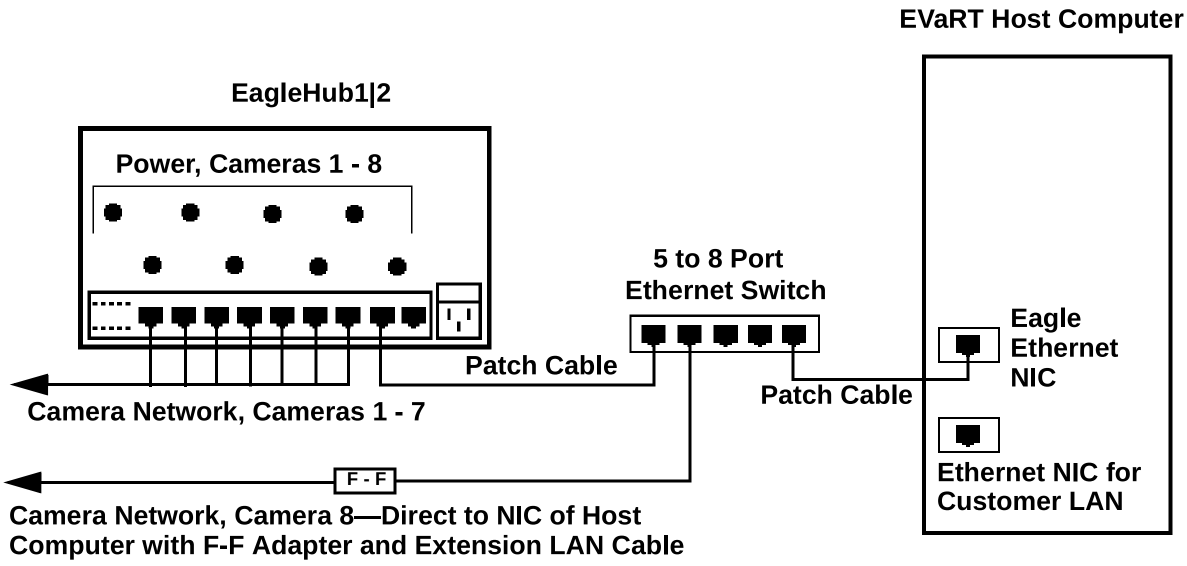
When first setting up your Eagle or Hawk system, you will notice that the both the power and Ethernet connections for the cameras are integrated through the EagleHub(s). The Eagle system allows for 8 cameras per each EagleHub1 or EagleHub2 (EagleHub1|2).

All camera power connectors are plugged into the power connectors of the EagleHub1|2. Order is not imperative as long as each power connector is close to an open Ethernet connector.

Note: The first seven cameras for each EagleHub1|2 are connected directly to the Ethernet connectors. The eighth camera must be connected to one of four ports of the Network Interface Card (NIC) on the rear of the host computer or to a separate Ethernet switch as shown in Figure A-5. This is done using a female to female (F-F) Ethernet adapter, and an extension Ethernet cable.

Important If using a frame rate greater than 120 Hz, you may only connect up to six cameras to any EagleHub1|2. Due to power considerations, using more than six cameras at high frame rates will dim the ring lights.

Figure A-5. Standard 8 Eagle or Hawk Camera, Single EagleHub1|2 Configuration


EVaRT Host Computer
EagleHub1|2
Power, Cameras 1 - 8
5 to 8 Port
Ethernet Switch
Eagle
Ethernet
NIC
Patch Cable
Patch Cable
Camera Network, Cameras 1 - 7
F - F
Ethernet NIC for
Customer LAN
Camera Network, Camera 8—Direct to NIC of Host
Computer with F-F Adapter and Extension LAN Cable

Note: If your Host Computer has a 4-Port NIC, you may connect the Patch Cable and the Camera 8 cable directly to it.

Note: If using the Uplink connector on the EagleHub to link to the Ethernet Switch, you must use a crossover cable.

Figure A-6. Uplink Hub Connector with Cross-Over Cable

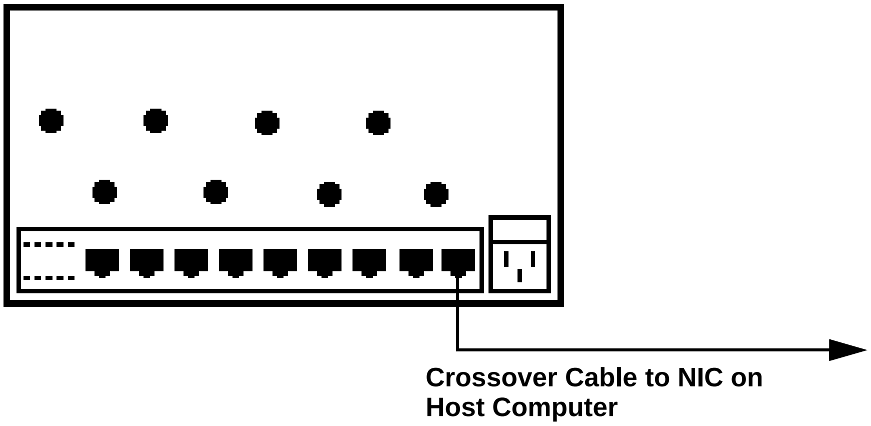
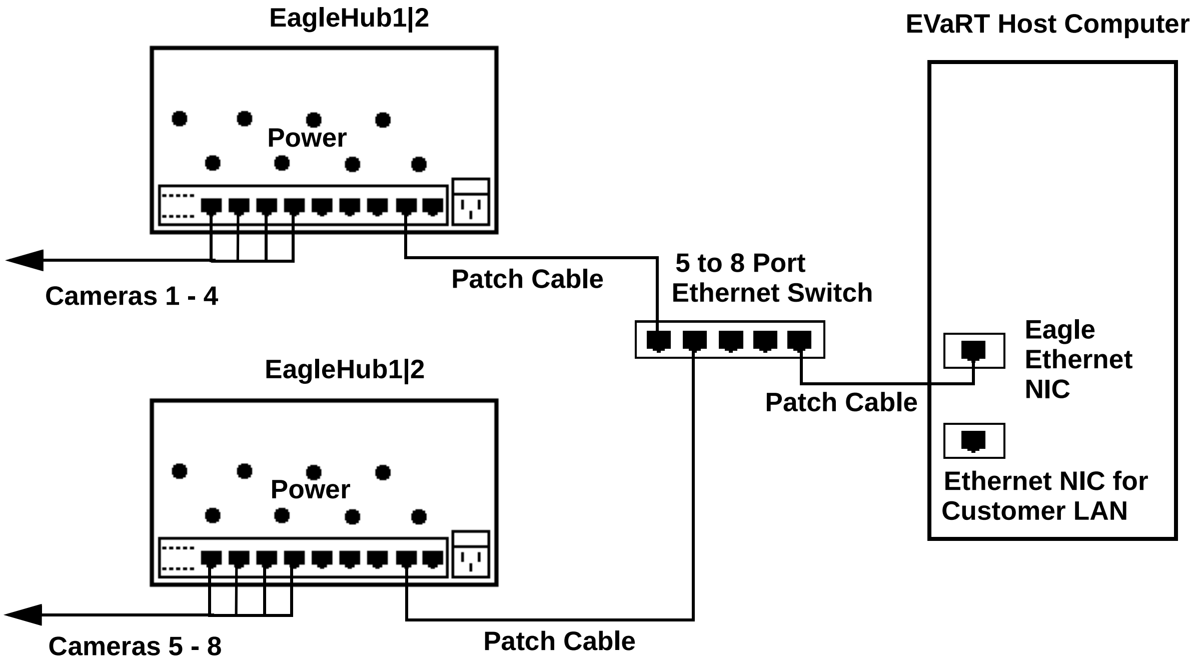

Crossover Cable to NIC on
Host Computer

Figure A-7. 8 Camera, 2 EagleHub1|2 Configuration


EagleHub1|2
Power
Cameras 1 - 4
Patch Cable
5 to 8 Port
Ethernet Switch
EVaRT Host Computer
Eagle
Ethernet
NIC
Patch Cable
Ethernet NIC for
Customer LAN
EagleHub1|2
Power
Cameras 5 - 8
Patch Cable

Note: If your Host Computer has a 4-Port NIC, you may connect the Patch Cables directly to it.

Using More than 8 Cameras

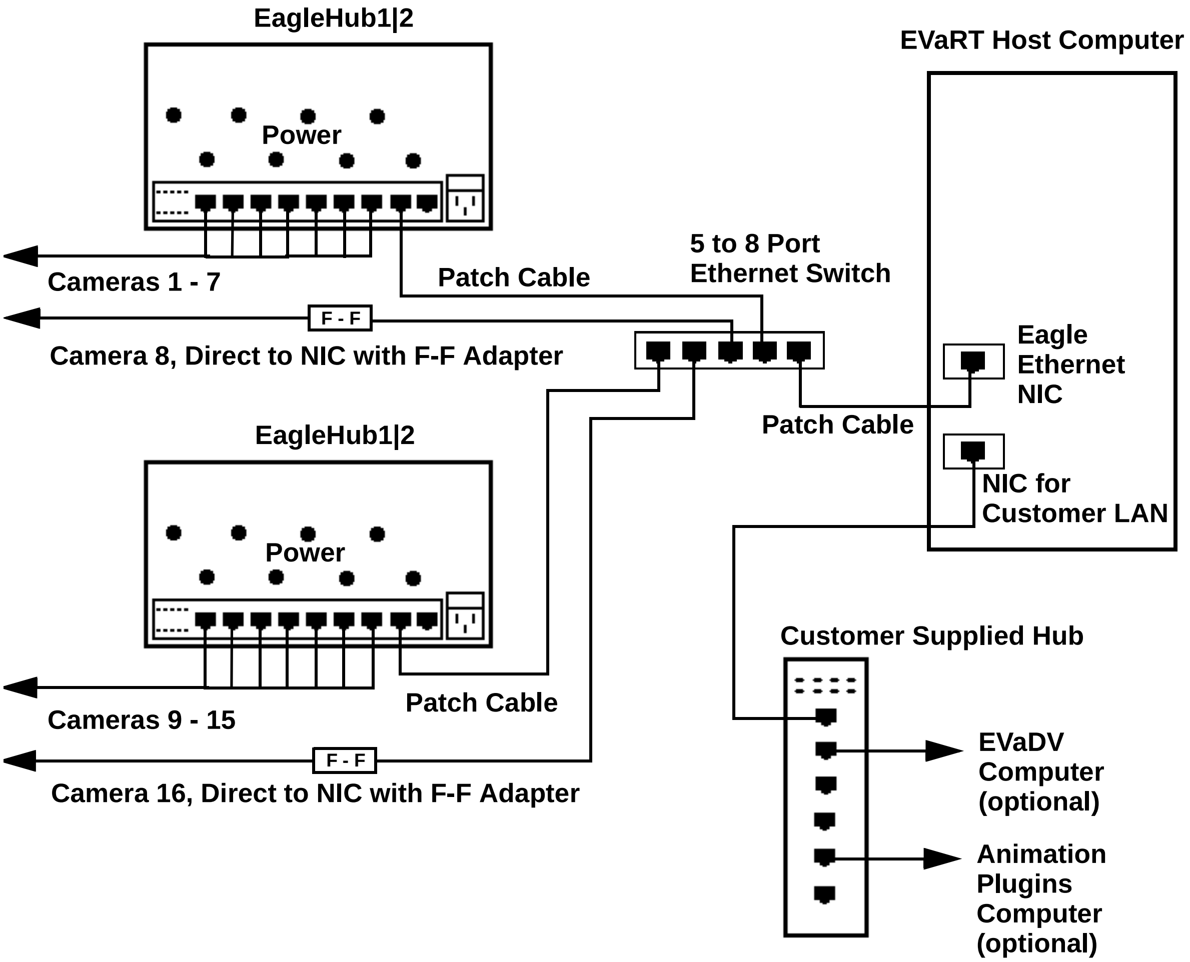
If using more than eight Eagle or Hawk digital cameras, you must use an additional EagleHub1|2 (i.e one EagleHub1|2 for every eight cameras). For example, if your system has 32 Eagle cameras, you will need four EagleHubs.

Each EagleHub1|2 configuration is the same for each 8 camera block, which then plugs into the NIC. For example, cameras 1 through 8 use Hub #1 and cameras 9 through 16 use Hub #2.

Note: If you are using two EagleHubs(1|2) for 16 cameras, you will need more than four NIC ports.

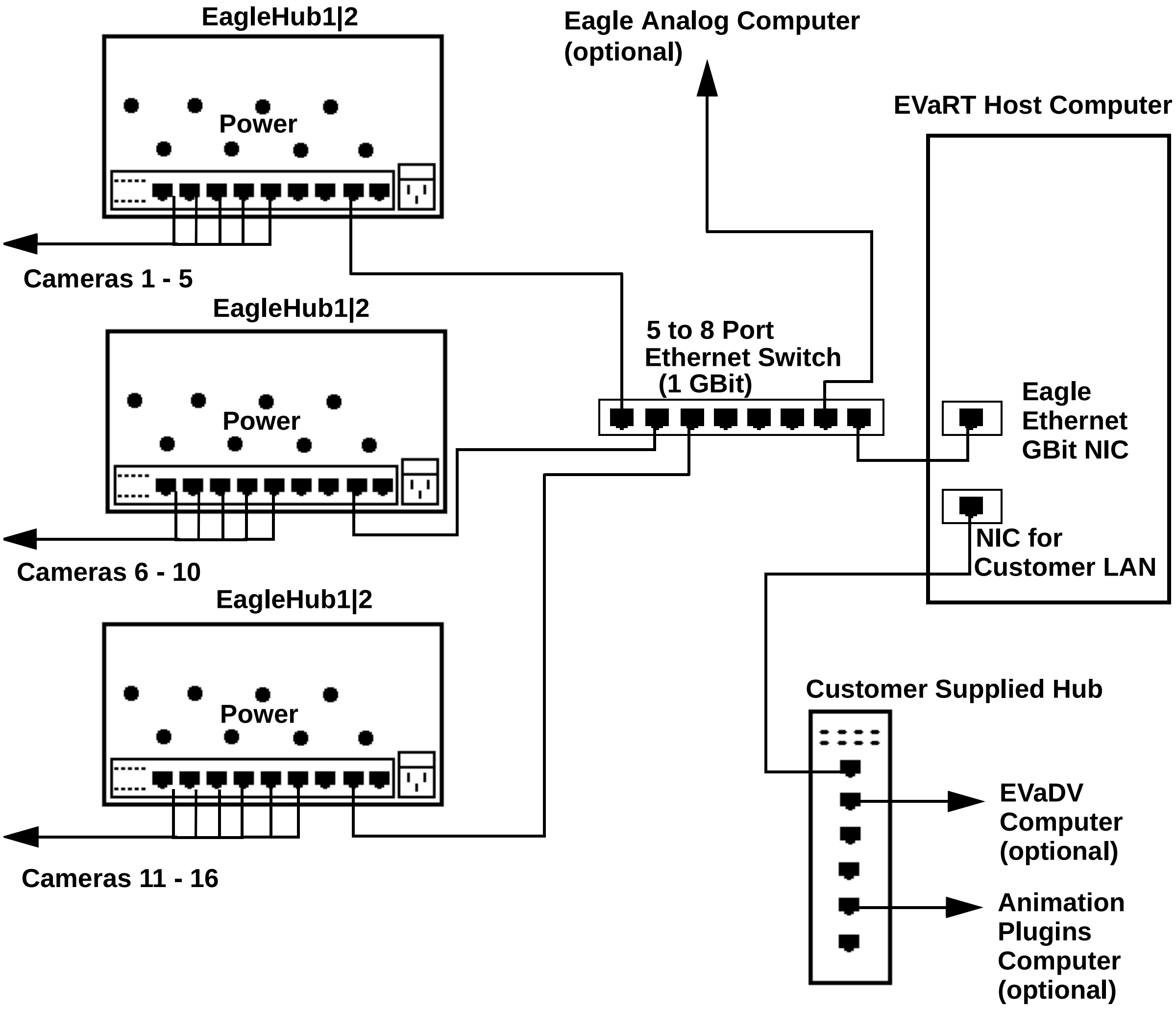
Note: If you are using an Eagle Analog Computer and two EagleHubs(1|2), the following setup (with one NIC) limits you to using 15 Eagle cameras. The fourth port on the NIC must be used for the Eagle Analog Computer, not the 16th camera.

Figure A-8. 16 Camera, 2 EagleHub1|2 Configuration


EagleHub1|2
Power
Cameras 1 - 7
Patch Cable
F - F
Camera 8, Direct to NIC with F-F Adapter
5 to 8 Port
Ethernet Switch
EVaRT Host Computer
Eagle
Ethernet
NIC
Patch Cable
NIC for
Customer LAN
EagleHub1|2
Power
Cameras 9 - 15
Patch Cable
F - F
Camera 16, Direct to NIC with F-F Adapter
Customer Supplied Hub
EVaDV
Computer
(optional)
Animation
Plugins
Computer
(optional)

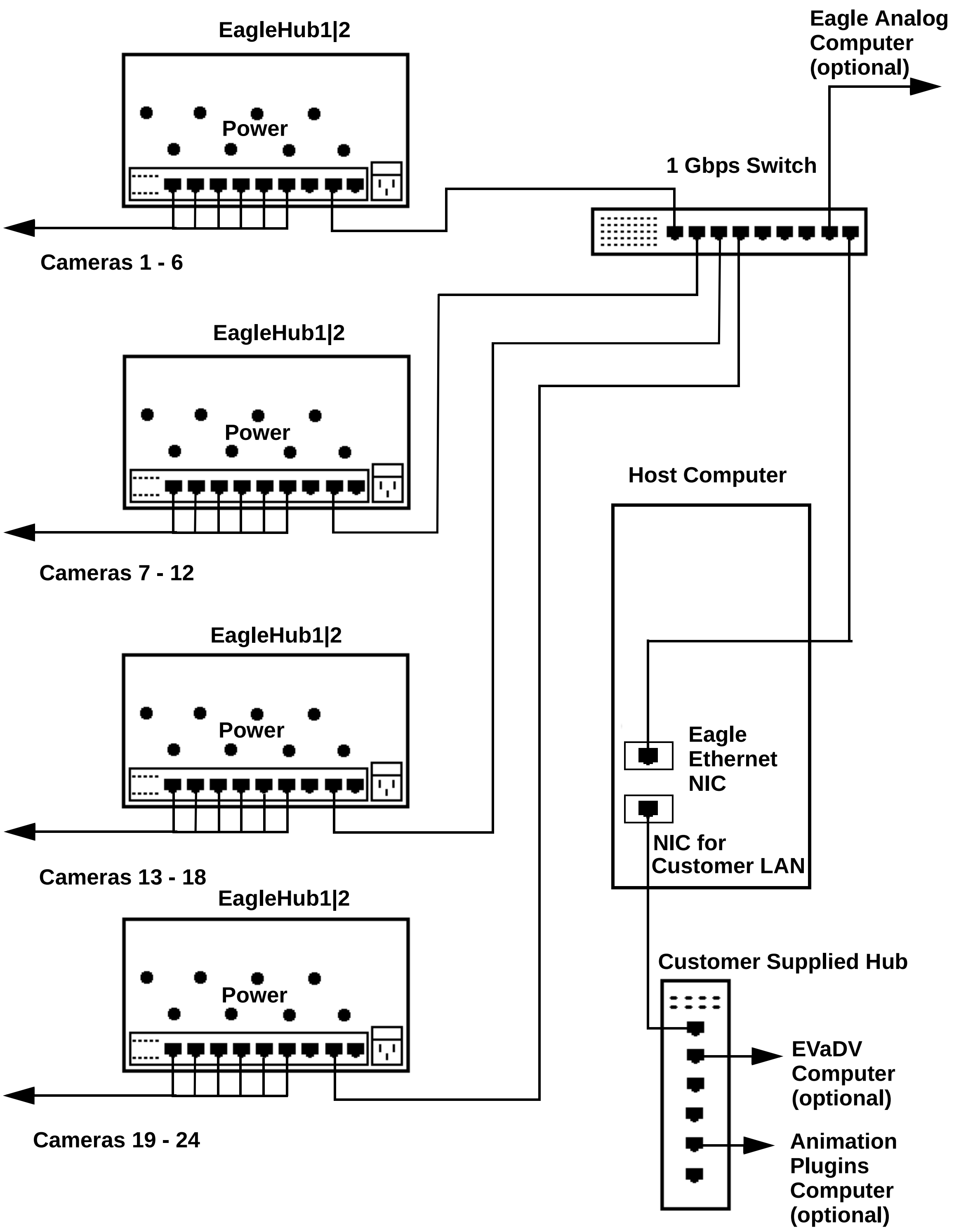
Note: If your Host Computer has a 4-Port NIC, you may connect the Patch Cables and 8th and 16th camera cables directly to it.

Figure A-9. 16 Camera, 3 EagleHub1|2 Configuration


EagleHub1|2
Power
Cameras 1 - 5
EagleHub1|2
Power
Cameras 6 - 10
EagleHub1|2
Power
Cameras 11 - 16
Eagle Analog Computer (optional)
5 to 8 Port Ethernet Switch (1 GBit)
EVaRT Host Computer
Eagle Ethernet GBit NIC
NIC for Customer LAN
Customer Supplied Hub
EVaDV Computer (optional)
Animation Plugins Computer (optional)

Note: If your Host Computer has a 4-Port NIC, you may connect the Patch Cables directly to it.

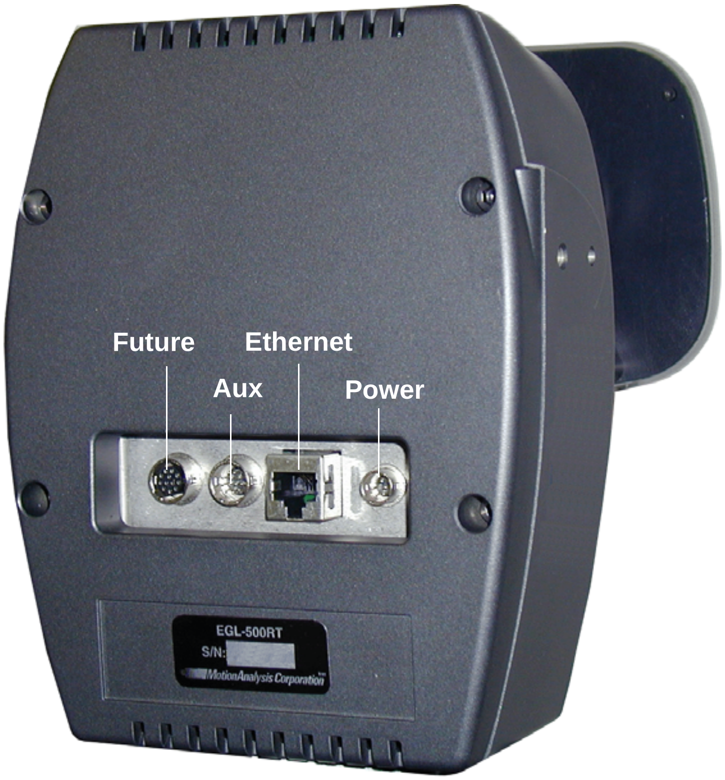
Figure A-10. 24 Camera, 4 EagleHub1|2 Configuration


EagleHub1|2
Power
Cameras 1 - 6
Eagle Analog Computer (optional)
1 Gbps Switch
EagleHub1|2
Power
Cameras 7 - 12
Host Computer
EagleHub1|2
Power
Cameras 13 - 18
Eagle Ethernet NIC
NIC for Customer LAN
EagleHub1|2
Power
Cameras 19 - 24
Customer Supplied Hub
EVaDV Computer (optional)
Animation Plugins Computer (optional)

Eagle and Hawk Digital Camera Connections

Eagle or Hawk digital cameras are connected to the EagleHubs using camera cables with both power and Ethernet connectors. When fitting connectors together, be sure the connections are secure and snap firmly into place.

Figure A-11. Eagle Rear Panel Connectors



Power Connector

The power connector powers the camera with a 48 Vdc source from the EagleHubs, through a CAT5 cable.

Ethernet Connector

The Ethernet connector is set for a 4-wire, full duplex 100 Mbps Ethernet.

Aux Connector

The Aux connector can be used for testing VGA and diagnostics and is generally not needed for normal customer use. An Aux cable is supplied with each Eagle and Hawk system which has three connectors on one end (VGA, COM 1, and BNC) for use in various applications and diagnostic testing.

Future Connector

The Future connector is reserved for future use.

Network Interface Cards and IP Addresses

Unless you are using a 1 Gbps hub (see Figure A-10) for a large number of cameras, your computer must have two Network Interface Cards (NIC):

1. Single port for your own LAN connection
2. 4-Port dedicated to the Eagle or Hawk system

Configuring a Network with Your Eagle Cameras

Single Port—For use with your LAN. If you are using the same 10.1.1.xxx addressing, you must use a fixed IP address. If you are using a different addressing scheme from what the Eagle and Hawk cameras are using, you can use DHCP (dynamic IP addressing).

In a command prompt window, you should be able to ping your Eagle and Hawk camera with the following:

```
> ping [IP address of camera]
```

For example, for a camera with an IP address of 10.1.1.205:

```
> ping 10.1.1.205
```

Entering the command `> IPCONFG` will tell you the status of your IP connections.

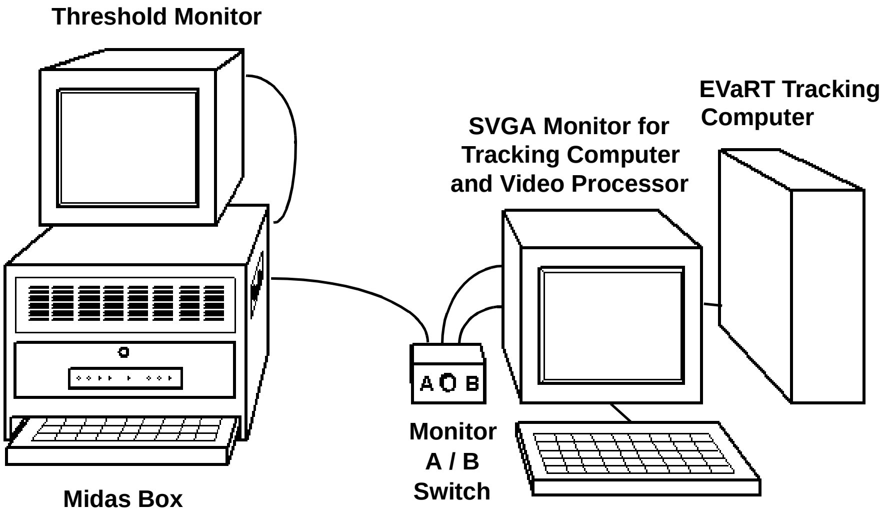
Dedicated Interface: Part of **Setup > Cameras > Eagle**. Use the IP address of the 4-port NIC that is connected to your Eagle cameras (10.1.1.199 is recommended).

Analog Camera System Configuration

Figure A-12 shows a standard **EVaRT** system using a Falcon, Pulnix, or Cohu digital camera. It includes:

- a Video Processor (MIDAS) computer
- a Tracking Computer (host)
- an SVGA Monitor shared by the Video Processor and Tracking Computer
- A MultiSync (Threshold) Monitor for viewing raw video data

Figure A-12. Standard Falcon, Pulnix, or Cohu System Configuration


Threshold Monitor
SVGA Monitor for Tracking Computer and Video Processor
EVaRT Tracking Computer
A B
Monitor A / B Switch
Midas Box

Power Consumption

The maximum power consumption you can expect for some typical system configurations is shown in Table A-2. The actual power consumed depends on the video frame rate and the intensity of the ring lights and is usually less than that indicated.

For the most reliable system operation, it is recommended that all camera assemblies and computers be powered by an uninterrupted power supply (UPS). If you want to save your data when power is lost altogether, you will also need to power the VGA monitor from the UPS.

Table A-2. Power Consumption of Some Typical Systems

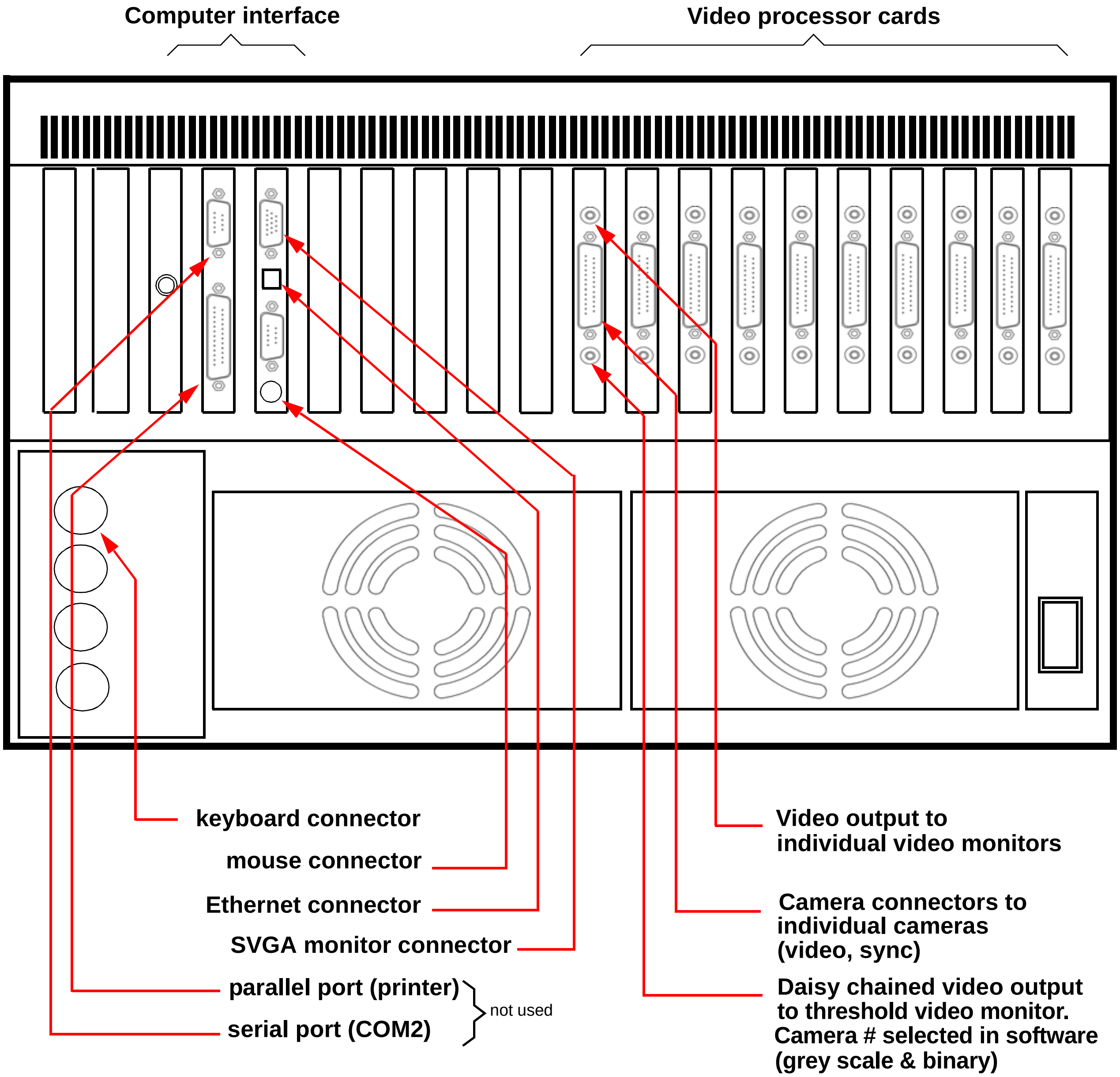
	6 Cameras	10 Cameras	16 Cameras
Falcon Camera Assy. 50 W max. each	300 W	500 W	800 W
Midas Computer with VPAT cards	200 W	250 W	300 W
21” VGA Monitor	125 W	125 W	125 W
21” Threshold Monitor	140 W	140 W	140 W
Dual Processor Computer	200 W	200 W	200 W
TOTAL	965 W	1215 W	1565 W

Video Processor (MIDAS) Connections

Back panel connections for a standard configuration of the Video Processor (**MIDAS** for **M**otion **I**ntegrated **D**ata **A**cquisition **S**ystem) are shown in figure A-13.

Note: Other configurations may have slightly different arrangements or have the position of the video processor cards and computer interface reversed.

Figure A-13. Video Processor (MIDAS) Connections


Computer interface
Video processor cards
keyboard connector
mouse connector
Ethernet connector
SVGA monitor connector
parallel port (printer)
serial port (COM2)
not used
Video output to individual video monitors
Camera connectors to individual cameras (video, sync)
Daisy chained video output to threshold video monitor. Camera # selected in software (grey scale & binary)

Analog Camera Connections

Video cameras are connected to the Video Processor using camera cables. There are two available cable configurations.

1. A camera cable with a 25-pin connector is connected directly to the Video Processor. Then, a long extension cable, with BNC connectors, is installed between this cable and the camera.
2. The long extension cable is connected to a back panel assembly rather than the camera cable described in Step 1.

Figure A-14. Standard Pig-Tail Cable

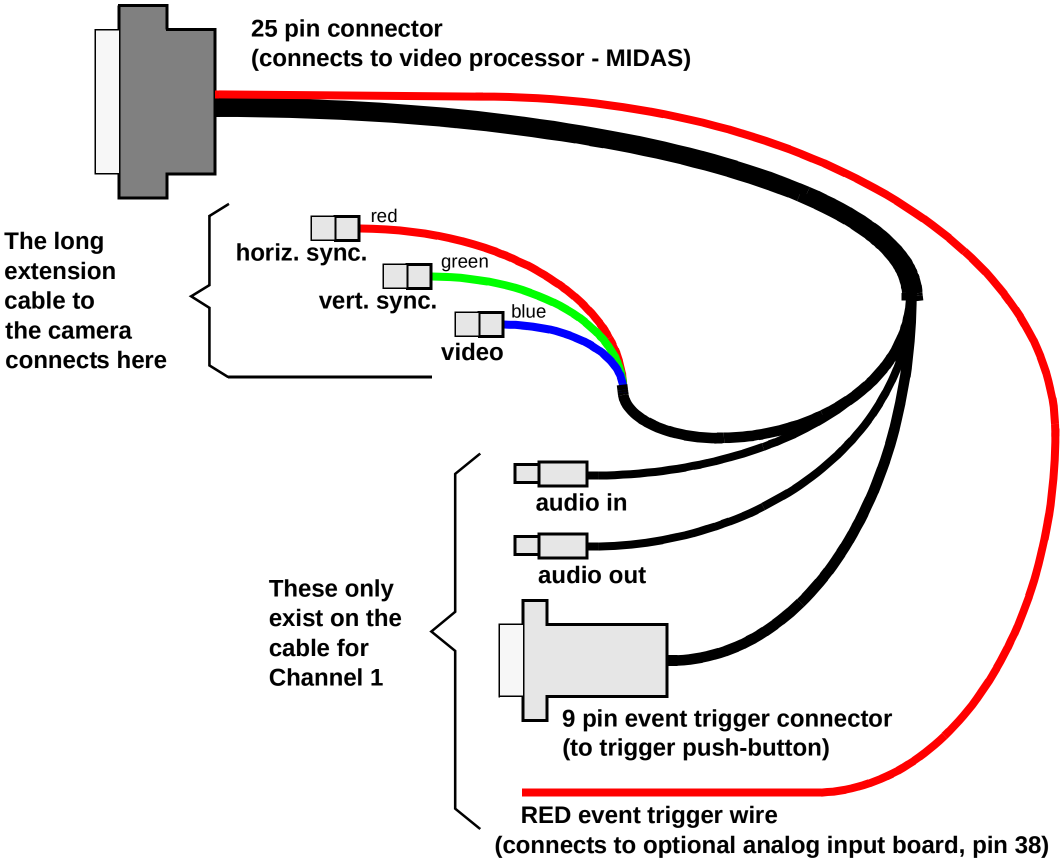
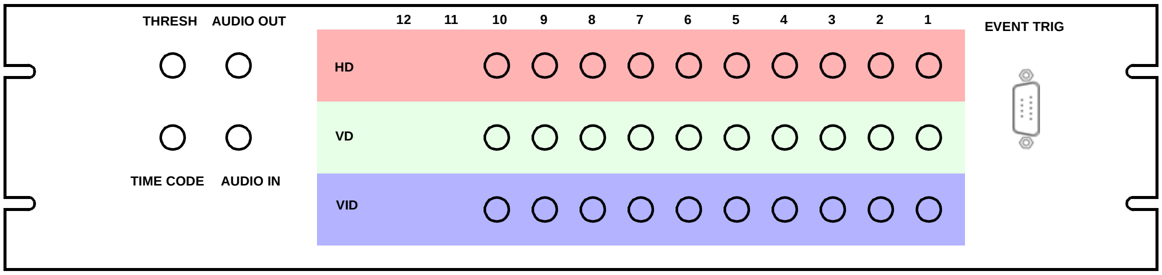

25 pin connector
(connects to video processor - MIDAS)
The long extension cable to the camera connects here
red
horiz. sync.
green
vert. sync.
blue
video
audio in
audio out
These only exist on the cable for Channel 1
9 pin event trigger connector
(to trigger push-button)
RED event trigger wire
(connects to optional analog input board, pin 38)

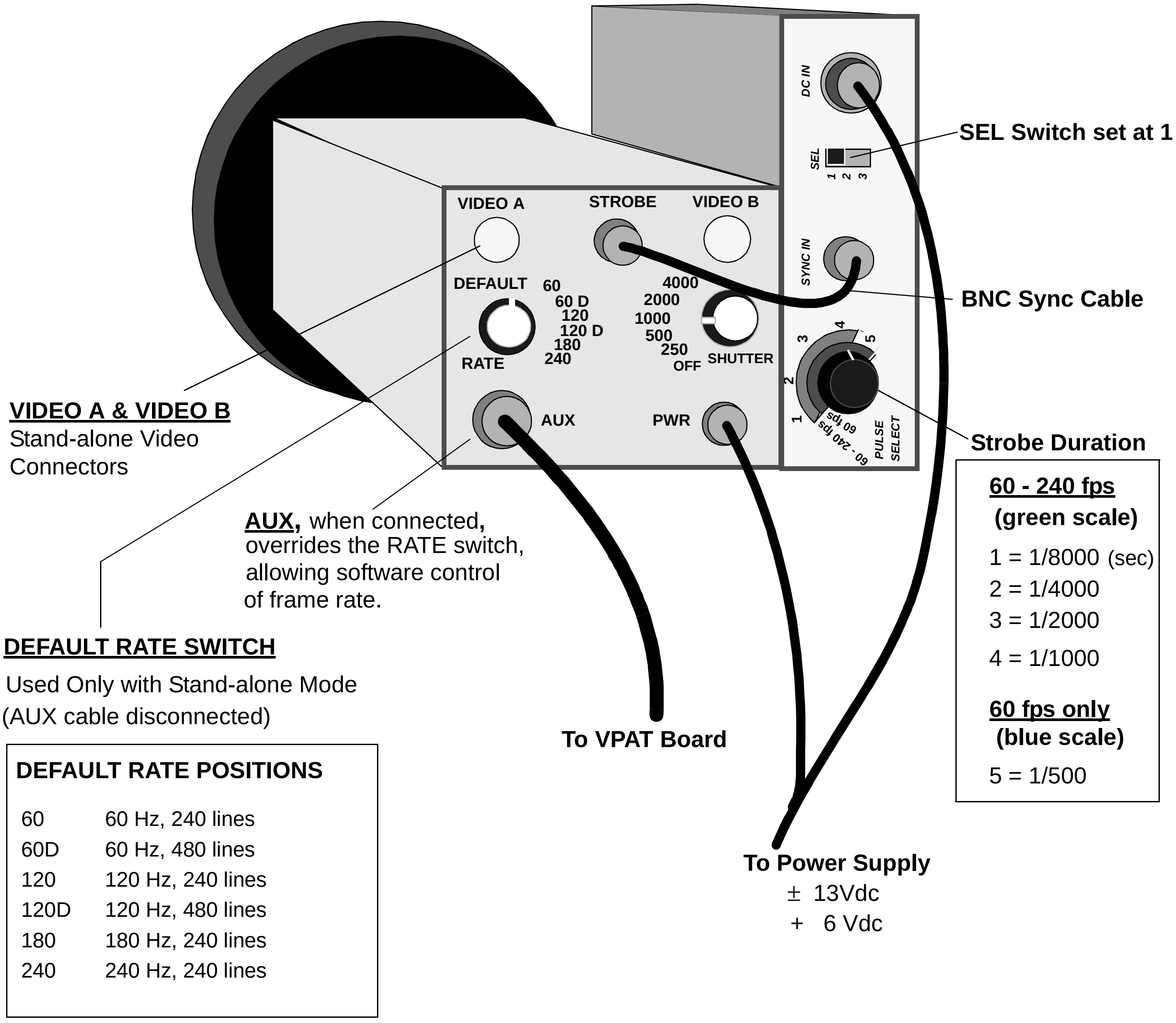
Figure A-15. Back Panel Camera Connector Assembly


THRESH
AUDIO OUT
12
11
10
9
8
7
6
5
4
3
2
1
EVENT TRIG
HD
VD
VID
TIME CODE
AUDIO IN

Connections to Specific Analog Cameras

The connections to a specific camera depends on the manufacturer. The individual red, green, and blue cables from the long extension cable are combined in short-stub cable specific to a particular type of camera. The following pages show diagrams for connecting to a variety of cameras.

Figure A-16. FALCON HR 240 Camera and Strobed LED Connections


VIDEO A
STROBE
VIDEO B
DEFAULT
RATE
60
60 D
120
120 D
180
240
4000
2000
1000
500
250
OFF
SHUTTER
AUX
PWR
DC IN
SEL
1 2 3
SYNC IN
1 2 3 4 5
60 fps
60 - 240 fps
PULSE SELECT
SEL Switch set at 1
BNC Sync Cable
Strobe Duration
To VPAT Board
To Power Supply
± 13Vdc
+ 6 Vdc

VIDEO A & VIDEO B
Stand-alone Video Connectors

AUX, when connected**,** overrides the RATE switch, allowing software control of frame rate.

DEFAULT RATE SWITCH
Used Only with Stand-alone Mode (AUX cable disconnected)

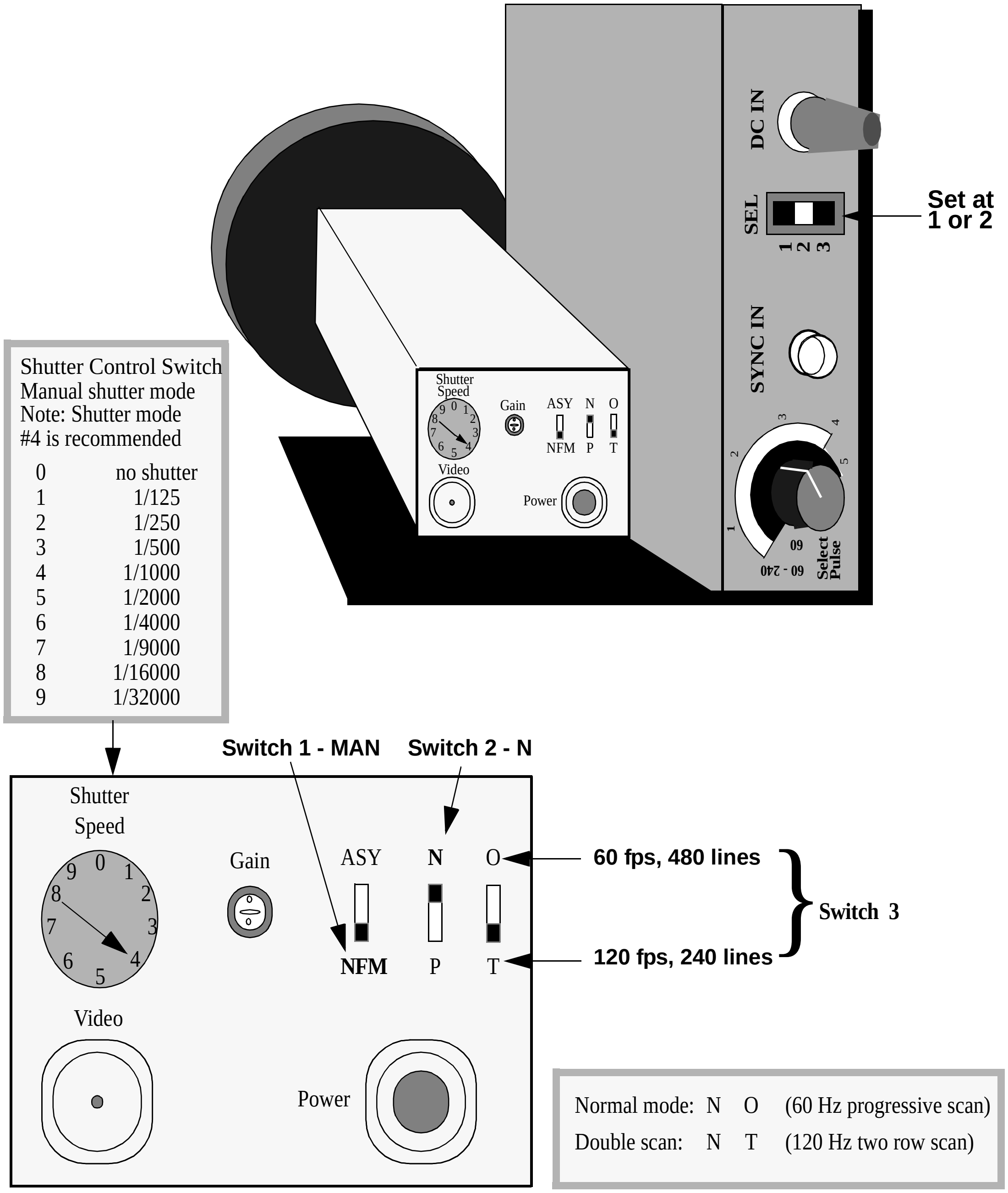
DEFAULT RATE POSITIONS

60	60 Hz, 240 lines
60D	60 Hz, 480 lines
120	120 Hz, 240 lines
120D	120 Hz, 480 lines
180	180 Hz, 240 lines
240	240 Hz, 240 lines

60 - 240 fps
(green scale)
1 = 1/8000 (sec)
2 = 1/4000
3 = 1/2000
4 = 1/1000

60 fps only
(blue scale)
5 = 1/500

Figure A-17. Pulnix Camera Switches and Connections


DC IN
SEL
1 2 3
Set at 1 or 2
SYNC IN
1 2 3 4 5
60
60 - 240
Select Pulse
Shutter Speed
0 1 2 3 4 5 6 7 8 9
Gain
ASY N O
NFM P T
Video
Power
Switch 1 - MAN
Switch 2 - N
60 fps, 480 lines
120 fps, 240 lines
Switch 3

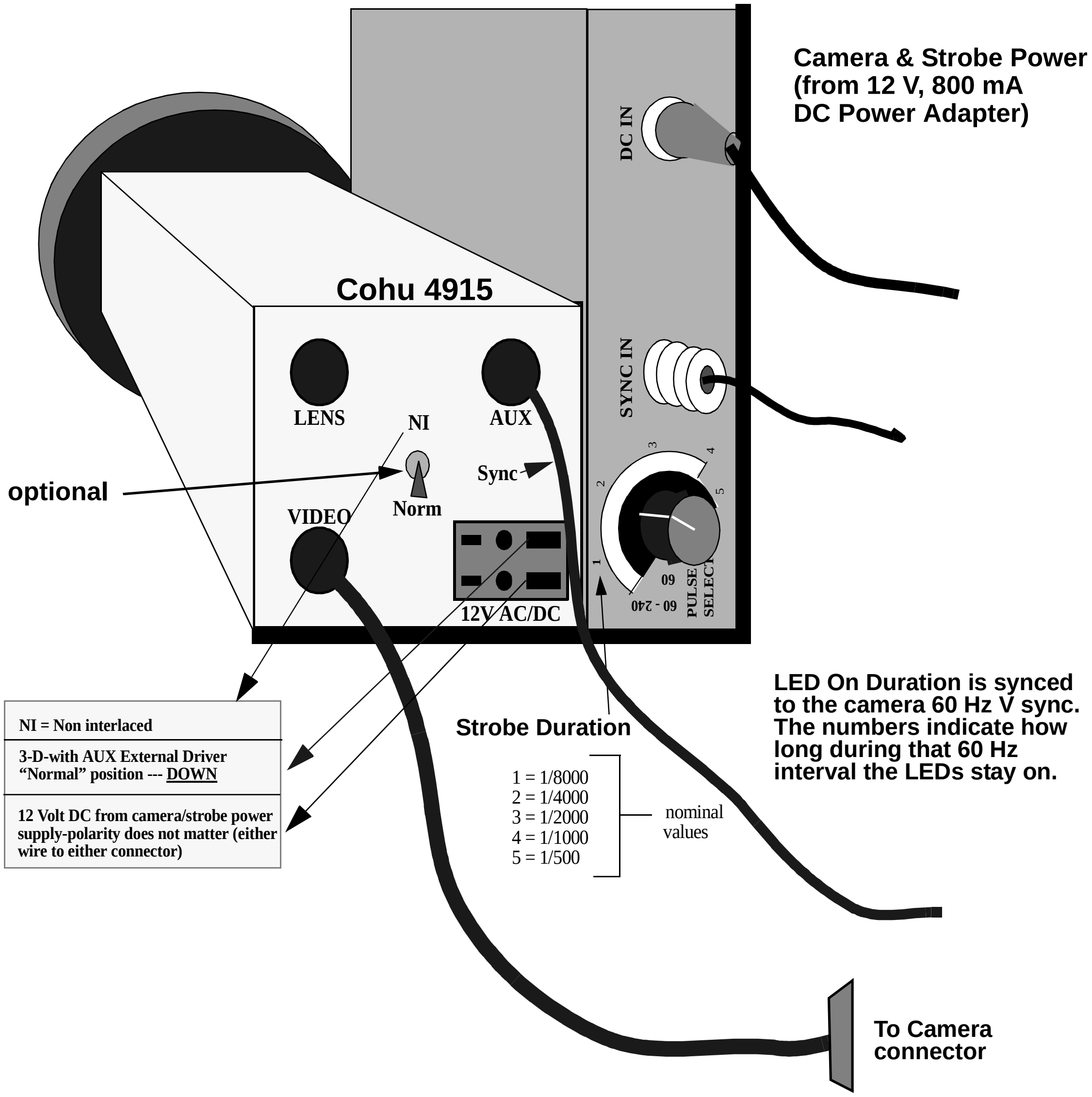
Shutter Control Switch
Manual shutter mode
Note: Shutter mode #4 is recommended

0	no shutter
1	1/125
2	1/250
3	1/500
4	1/1000
5	1/2000
6	1/4000
7	1/9000
8	1/16000
9	1/32000

Normal mode:	N	O	(60 Hz progressive scan)
Double scan:	N	T	(120 Hz two row scan)

Figure A-18. Cohu 4915 60 Hz Camera Connections

(Inside Select Switches)
before Revision E


Cohu 4915
LENS
NI
AUX
Sync
Norm
VIDEO
12V AC/DC
DC IN
SYNC IN
1
2
3
4
5
60
60 - 240
PULSE SELECT
optional

Camera & Strobe Power (from 12 V, 800 mA DC Power Adapter)

NI = Non interlaced

3-D-with AUX External Driver
“Normal” position --- DOWN

12 Volt DC from camera/strobe power supply-polarity does not matter (either wire to either connector)

Strobe Duration

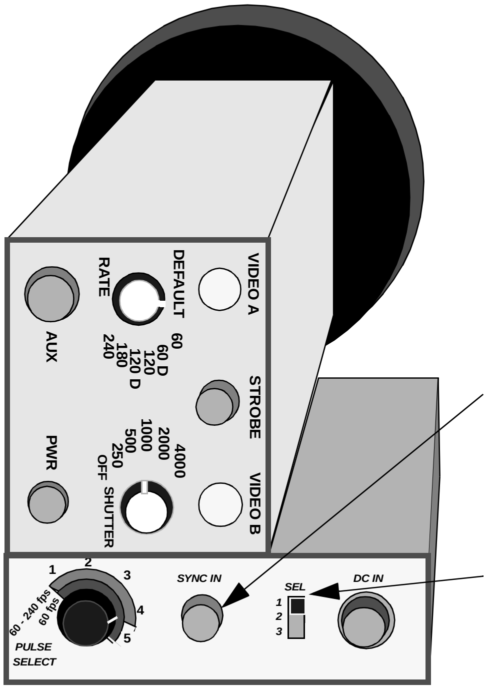
1 = 1/8000
2 = 1/4000
3 = 1/2000
4 = 1/1000
5 = 1/500

nominal values

LED On Duration is synced to the camera 60 Hz V sync. The numbers indicate how long during that 60 Hz interval the LEDs stay on.

To Camera connector

Figure A-19. Summary of Camera and Strobe Settings


VIDEO A
DEFAULT
RATE
60
60 D
120
120 D
180
240
AUX
STROBE
4000
2000
1000
500
250
OFF
SHUTTER
PWR
VIDEO B
1
2
3
4
5
60 - 240 fps
60 fps
PULSE
SELECT
SYNC IN
SEL
1
2
3
DC IN

Revision B & C
(Earlier version - Does not have external Select Switch)
Dip Switches located inside the Strobe Control Box.
Remove Cover For Access To Dip Switches.

Revision E Strobe Select Switch
(Latest version available - effective May 19, 1994)
Slide switch to desired position

	Type of Strobe with Switch Setting per Camera Type	
Type of Camera	**Strobe Revision B & C Dip Switch Settings**	**Strobe Revision E SEL Switch Position**
FALCON HR 240	N/A	Position 1 (top)
Pulnix TM-6701AN-534	1 & 2 OFF, 3 & 4 ON	Position 2 (middle)
COHU 4915 W/SW	1 & 2 ON, 3 & 4 OFF	Position 1 (top)

Figure A-20. Push-Button Switch For Eagle or Hawk System

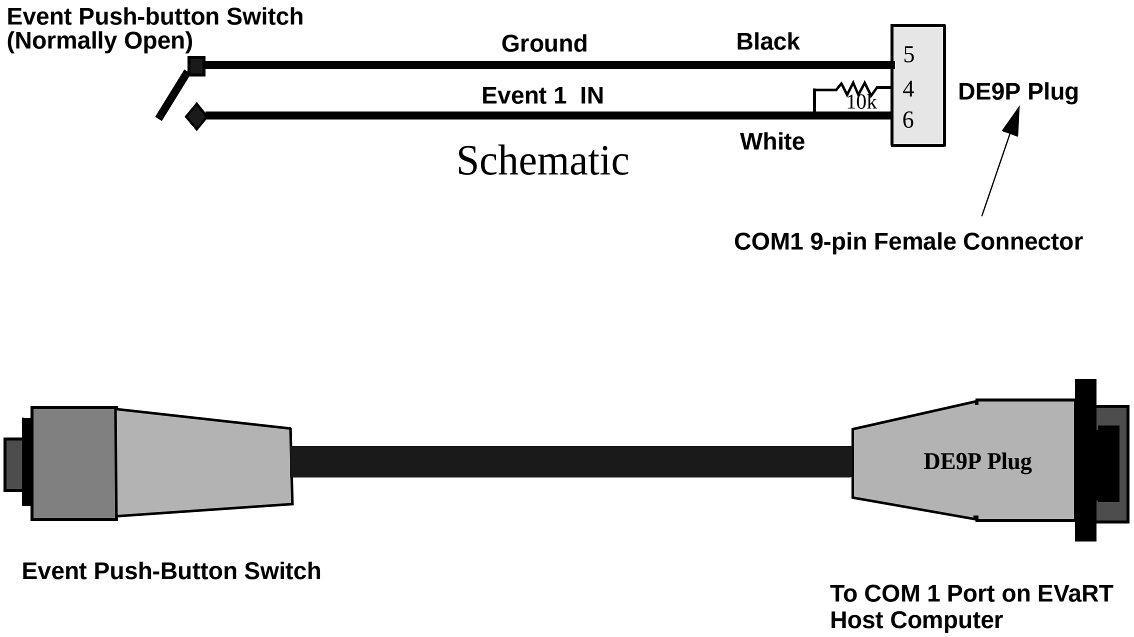
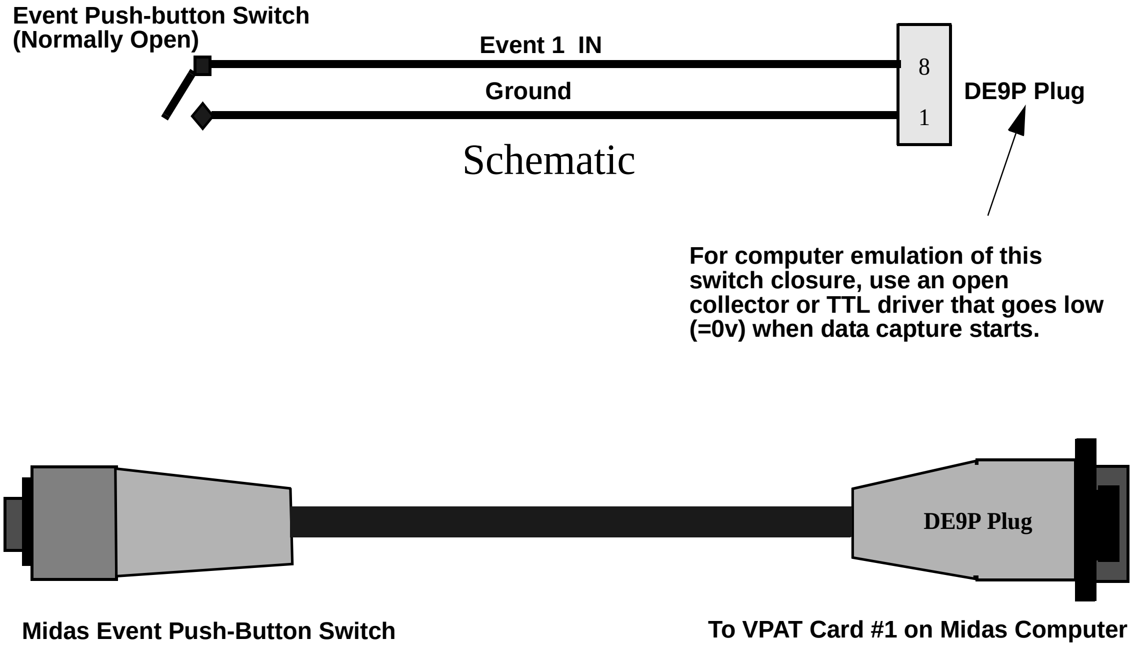

Event Push-button Switch
(Normally Open)
Ground
Black
5
4
6
Event 1 IN
10k
White
DE9P Plug
Schematic
COM1 9-pin Female Connector
DE9P Plug
Event Push-Button Switch
To COM 1 Port on EVaRT
Host Computer

Figure A-21. Push-Button Switch For Midas System


Event Push-button Switch
(Normally Open)
Event 1 IN
Ground
8
1
DE9P Plug
Schematic
DE9P Plug
Midas Event Push-Button Switch
To VPAT Card #1 on Midas Computer

For computer emulation of this switch closure, use an open collector or TTL driver that goes low (=0v) when data capture starts.

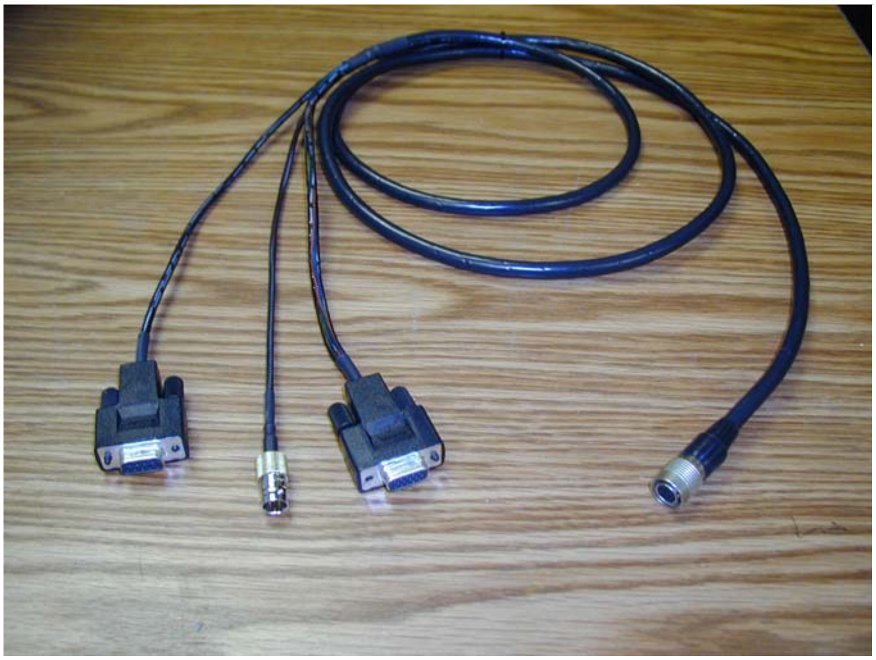
Configuring Ringlight Changes for Eagle and Hawk Cameras

If you change the ringlight on your Eagle or Hawk camera, you must tell the camera what kind of ringlight it currently has attached. If you do not, it could send too much power to the ringlight and damage the electronic circuitry or LEDs.

Parts You Will Need

1. Computer with COM port and HyperTerminal software (standard with Windows).
2. Eagle/Hawk Test Cable (shown below) that came with your Eagle or Hawk system. This cable is about 6 feet long, has special connector one end to plug into the back of the camera. The other end has three connectors: a 9 pin COM port, a 15 pin VGA, and single BNC.

Figure A-22. Eagle/Hawk Test Cable



Steps

1. Put the camera on a table, connect the single connector end of the Eagle/Hawk Test cable to the back of the camera.
2. Connect the Eagle/Hawk Test cable's COM port to the COM1 port of your computer. COM2 may also be used.
3. Launch HyperTerminal. If you have installed **EVaRT**, there should be a file named **EagleCOM1.ht** in the folder containing the **EVaRT** executable (for example: **C:\Program Files\Motion Analysis\EVaRT50\EagleCOM1.ht**. Double click on the HT file name and HyperTerminal should launch. If you are on a different computer, look from the Start Menu under **Programs > Accessories > Communications > HyperTerminal**. This allows you to view and type messages to the

software in the Eagle or Hawk camera. You must quit **EVaRT** (or uncheck **Motion Capture > Output: > Enable External Trigger** to free up the COM1 port. COM port settings: 9600 8-N-1.

4. Boot the camera by plugging it into the EagleHub or turning the power off and on to your EagleHub. After a few seconds you should see messages similar to the following example:

```
* * * * * * * * * * * * * * * * * * * * * * * *

* MAC Camera Control Program

* Camera Configuration version 1.4  copyright
  (c) 2003, Motion Analysis, Inc.

* NET+WORKS Version 3.00  copyright (c) 2000,
  NETsilicon, Inc.

* * * * * * * * * * * * * * * * * * * * * * * *

Serial channel used for diagnostics will use a
baud rate of 9600.

After the camera board is reset, the camera
will wait 5 seconds for the user to signal any
changes on the keyboard.

- - - - - - - - - - - - - - - - - - - - - - - -

Press any key within 5 seconds to change these
settings.
```

5. Press the Space bar (or any other key) to change the camera configuration.
6. Press **M** to modify the camera settings
7. Press **Enter** about 5 times to leave the other settings unchanged. Wait for the message that tells which Ringlight is currently configured. If the ringlight type is infrared, then the display should be ***Ringlight type = infrared. (7***). If the ringlight type is red, then the display should be ***Ringlight type = red. (1).*** For example, to change from: near Infrared (4) to red (1), type in the 1 character as:

   Ringlight type = near infrared. (4) 1
   (You type in the single digit 1 followed by Return)

8. Press **Enter** to leave the other items unchanged.
9. Wait for the camera to boot again and check that Ringlight type was successfully changed.

Appendix B Analog Input Hardware and Software

Topic	Page
Overview	B-1
Installing NIDAQ Software on an EVaRT Computer	B-3
Analog Signal Naming Conventions	B-4
32-Channel, 16-Bit NI USB-6218 Configuration	B-5
64-Channel SCB-100 and NI PCI-6071E Configuration	B-14

Overview

The **EVaRT** system can accept analog data from external devices and synchronize it with video motion data.

Analog cards known to work with **EVaRT** software include the following A-D configurations and the necessary NIDAQ software. **EVaRT** will support one or two of the devices listed in Table B-1. The devices must have the same resolution (12-Bit or 16-Bit). Other NI Analog A-D input configurations should work but have not been tested.:

Table B-1. A-D Configurations Used with EVaRT Software

A-D Configuration	NIDAQ Software
NI USB-6218, 32-Channel, 16-Bit (up to 6 USB devices)	NIDAQ 8.3 or later, EVaRT 5.0.3 or later
NI PCI-6071E, 64-Channel, 12-Bit	Traditional NIDAQ 7.0 > 7.4, EVaRT 4.4
NI PCI-6071E, 64-Channel, 12-Bit (higher performance)	NIDAQ MX 8.0 or later, EVaRT 5.0
NI DAQ Card-6024E, 16-Channel, 12-Bit	Traditional NIDAQ 7.4, EVaRT 4.6
NI PCI 6254, 32-Channel, 16-Bit (up to 2 cards)	NIDAQ MX 8.0 or later, EVaRT 5.0
NI USB-6259, 32-Channel, 16-Bit (up to 2 USB devices)	NIDAQ 8.1 or later, EVaRT 5.0.2

Note: If you are using NIDAQ MX 8.0 or 8.1 versions and if you are collecting data for only one channel in **EVaRT**, you will need to install a jumper wire from screw terminals PFI 7 to PFI 0 on the A-D interconnect box. This may be changed in future versions of the NI software drivers. If you have two analog acquisition devices installed, the same is applied for each device: If only one channel is sending data on that device, the PFI7 to PFI0 jumper must be installed.

This appendix documents both of the 32-channel (16-bit) setups and the 64-channel setups of analog input available, accessed by means of the Analog Terminal Box which contains 100 screw terminals. The 32-channel setups are also broken down to USB and PCI connections. A list of the location of channel numbers in the Analog Terminal Box for digital camera systems is given for each type of A-D setups. You may find it useful to make a copy of this chart and use the column titled Setup Name to record the connections for your installation. The connections for a typical application using two AMTI Force Plates and ten EMG channels for digital cameras is shown for each setup.

Although connecting analog inputs is not particularly difficult, it is important that certain naming conventions be followed for the external data to work smoothly with supplementary Motion Analysis software such as **KinTrak** and **OrthoTrak**. This is described in "Analog Signal Naming Conventions" on page B-4.

Performance Specifications

The Motion Analysis Digital Camera system is capable of collecting up to 192 channels of analog data at any frequency between 60 and 5000 Hz. In newer systems, using the NIDAQ MX 8.0 or later software, analog rates can be much higher. The maximum rate can be up to 255 times the video capture rate, but performance may vary with different computers. The master digital camera provides the clocking signals to the A-D card in the A-D computer, which provides the phase-locking mechanism. You must connect the A-D cable from the master camera to the A-D interconnect box. Data can be collected in the pause mode or the run (live) mode, without any delay or drift between analog and video signals.

Separate A-D Computer

This configuration is no longer supported in the **EVaRT 5.0** software. Please consult support@motionanalysis.com for further details.

Installing NIDAQ Software on an EVaRT Computer

For a new installation, start with Step 4 below. For **EVaRT 5.0** and later software, we recommend installing NIDAQ version 8.0 or later as it gives better analog performance and allows higher analog sample rates. With NIDAQ 7.1 through 7.4, the maximum analog sample rate is 5000 samples/sec for all channels. With NIDAQ 8 and above, you can go to higher rates (typically 20,000 samples per second) for all channels.

Note: NIDAQ version 7.5 DOES NOT WORK with any version of **EVaRT**. Versions of NIDAQ software are available for downloading from www.ni.com.

If NIDAQ Software is Already Installed

1. Shutdown/power OFF the computer and remove the A-D card.
2. Power ON the computer, go to **START/Settings/Control Panel, Add/Remove Programs,** select **NI_DAQ** and then select **Remove**.
3. When complete, shutdown/power OFF the computer, wait 10 seconds, power ON the computer, let the system boot up, and then log-in when prompted. It is necessary to have the computer boot without the A-D card or software. Proceed to the next step.

New Installation of NIDAQ Software

1. Install the **NI-DAQ software, version 8.0 or later**. Install all of the default entities that are checked, then shutdown/power OFF the computer. Note that **EvaRT 5.0** + users can use either NIDAQ 7.1 through 7.4 or NIDAQ 8.0 or later. NIDAQ 8 allows higher sample rates and better overall analog performance. **EvaRT 5.0** uses the newer NIDAQ MX libraries whereas earlier versions of **EVaRT** use the "Traditional" (Legacy) NIDAQ libraries. Also, note that NIDAQ 7.5 does not work at all with **EVaRT** applications.
2. Power ON the computer and let it boot completely without the A-D card installed. This will complete the National Instruments software installation. Once the computer is completely booted, Shutdown/power OFF the computer once again.
3. Install the A-D card and power ON the computer. It should come up with the Hardware Wizard and the "Found new hardware" pop-up window. At this point, the computer will automatically install the NI-DAQ drivers correctly.
4. Shutdown/power OFF the computer one last time and then power it back ON.
5. Go to the National Instruments Test and Measurements software and select Traditional NIDAQ devices and then right click and select test panel.
6. Run through some of the channels to verify that the board is seeing the data. (test by having someone step on the forceplate).
7. Close and launch **EVaRT** and connect to cameras. You should see that all cameras are found as well as the A/D.

Note: If you have NIDAQ 7.0 + drivers already installed onto your system, it is not necessary to un-install the software when upgrading.

Analog Signal Naming Conventions

When connecting force plates and EMG equipment to the **EVaRT** system, certain requirements must be met and conventions followed.

Typically, forceplates are connected to the first channels of the A/D system and then the EMG channels. Specific Analog signal names for the forceplates must be used if **KinTrak** and **OrthoTrak** are used. These names depend on the forceplate manufacturer.

Kistler Forceplates

8 channels per plate:

- Analog Channel 1 connects to the F1X1 signal.
- Analog Channel 2 connects to the F1X3 signal, etc.

If there are two plates:

- Analog Channel 9 connects to the F2X1 signal.
- Analog Channel 16 connects to the F2Z4 signal.

The reserved names for **OrthoTrak** and **KinTrak** are:

PLATE #1: F1X1 F1X3 F1Y1 F1Y2 F1Z1 F1Z2 F1Z3 F1Z4
PLATE #2: F2X1 F2X3 F2Y1 F2Y2 F2Z1 F2Z2 F2Z3 F2Z4

Note: These naming conventions are already set up in the Analog sub-panel.

For AMTI or Bertec Forceplates

6 channels per plate:

- Channel 1 connects to the F1X signal.
- Channel 2 connects to the F1Y signal.
- Channel 6 connects to the M1Z signal.

If there are two plates, it connects to Channels 7 through 12. The reserved names for **OrthoTrak** and **KinTrak** are:

PLATE #1: F1X F1Y F1Z M1X M1Y M1Z
PLATE #2: F2X F2Y F2Z M2X M2Y M2Z

EMG Signal Name Conventions

For **KinTrak**, you must specify the channel names in the **KinTrak** project definition as well as in the **EVaRT** analog setup screen, which is saved in the **EVaRT** project file.

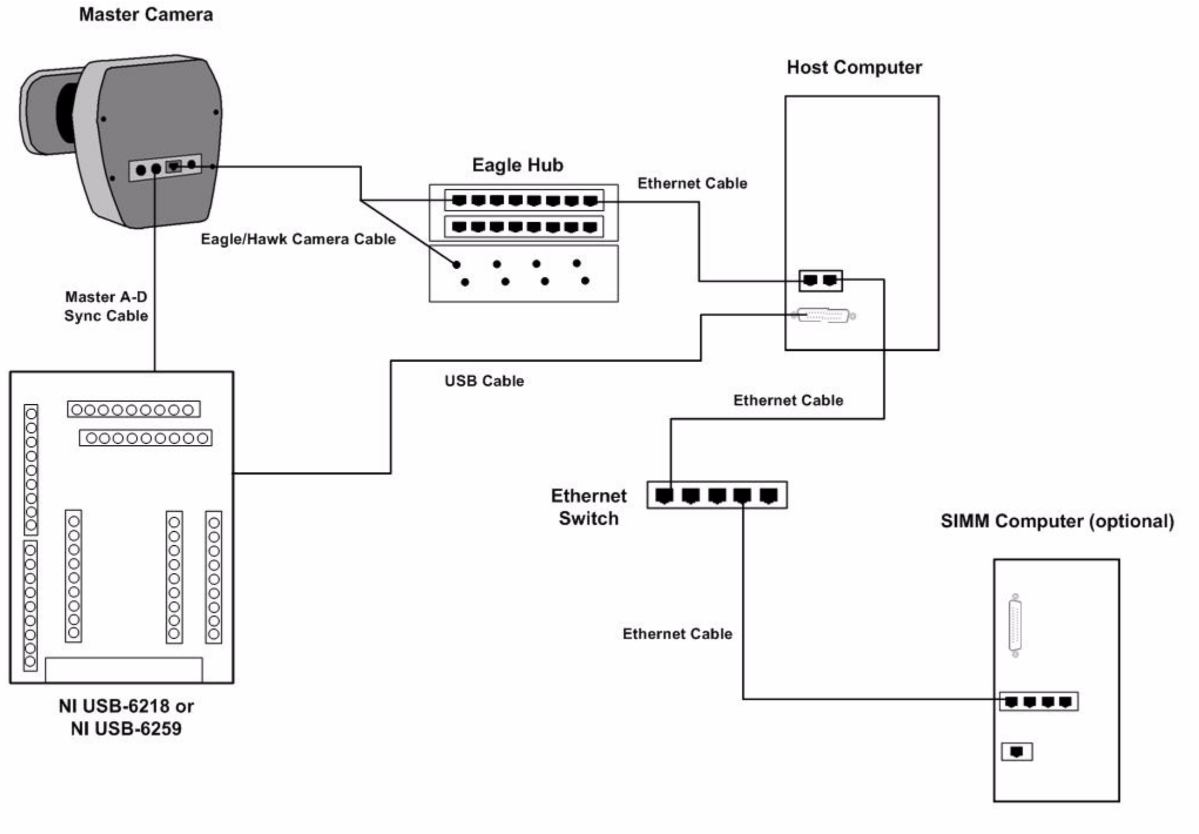
See the **OrthoTrak Reference Manual** for **OrthoTrak** muscle name conventions.

32-Channel, 16-Bit NI USB-6218 Configuration

Note: The following has been tested on Windows XP Pro and Windows 2000 Pro with the latest web-based updates from Microsoft. The **EVaRT** software will support up to 6 USB devices and up to 192 channels of analog input. USB 2.0 ports work best. USB 1.0 ports will also work but with reduced data rates.

Note: Up to 2 cards can be installed into the host computer. The Sync Cable must be connected to both cards.

Figure B-1. 32-Channel, 16-Bit A-D Hardware Setup for the USB-6218 A-D Card


Master Camera
Host Computer
Eagle Hub
Ethernet Cable
Eagle/Hawk Camera Cable
Master A-D
Sync Cable
USB Cable
Ethernet Cable
Ethernet
Switch
SIMM Computer (optional)
Ethernet Cable
NI USB-6218 or
NI USB-6259

First: Install the Software

Before you plug the NI USB device into the host computer, you must first install the NI Acquisition software. You need to have installed the **NIDAQ software version 8.3** (or later) and you must be using **EVaRT 5.0.3 or later** for using the NI-USB 6218 A-D device. Install the National Instruments software, accept all the defaults, then let it finish and re-boot your computer. This may take 10-15 minutes. The remainder of the process takes less time. For more information, please refer back to “Installing NIDAQ Software on an EVaRT Computer” on page B-3.

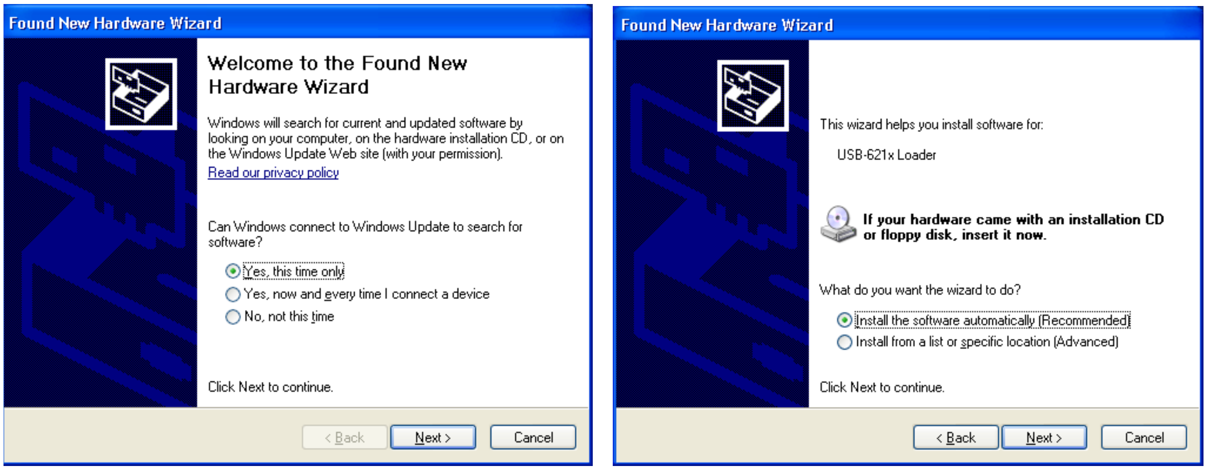
Second: Install the Hardware

1. Plug in the A-D device (NI USB-6218 will be used as the example below).
2. You will then automatically go through the "Found New Hardware Wizard" operation for a USB-device.

Note: You will do this two times. The first round is for the 621x Loader. The next round is then for the 6218 Device.

3. Select **Yes, this time only**, then **Next >.**

Figure B-2. Found New Hardware Wizard Interface—First Round



Found New Hardware Wizard

Welcome to the Found New Hardware Wizard

Windows will search for current and updated software by looking on your computer, on the hardware installation CD, or on the Windows Update Web site (with your permission).

Read our privacy policy

Can Windows connect to Windows Update to search for software?

● Yes, this time only
○ Yes, now and every time I connect a device
○ No, not this time

Click Next to continue.

Found New Hardware Wizard

This wizard helps you install software for:

USB-621x Loader

If your hardware came with an installation CD or floppy disk, insert it now.

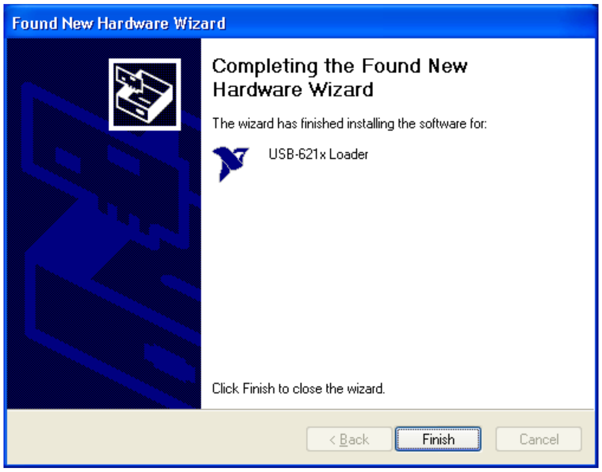
What do you want the wizard to do?

● Install the software automatically (Recommended)
○ Install from a list or specific location (Advanced)

Click Next to continue.

4. Click **Next >** then **Finish**.

Figure B-3. Completing the Found New Hardware Wizard Interface



Found New Hardware Wizard

Completing the Found New Hardware Wizard

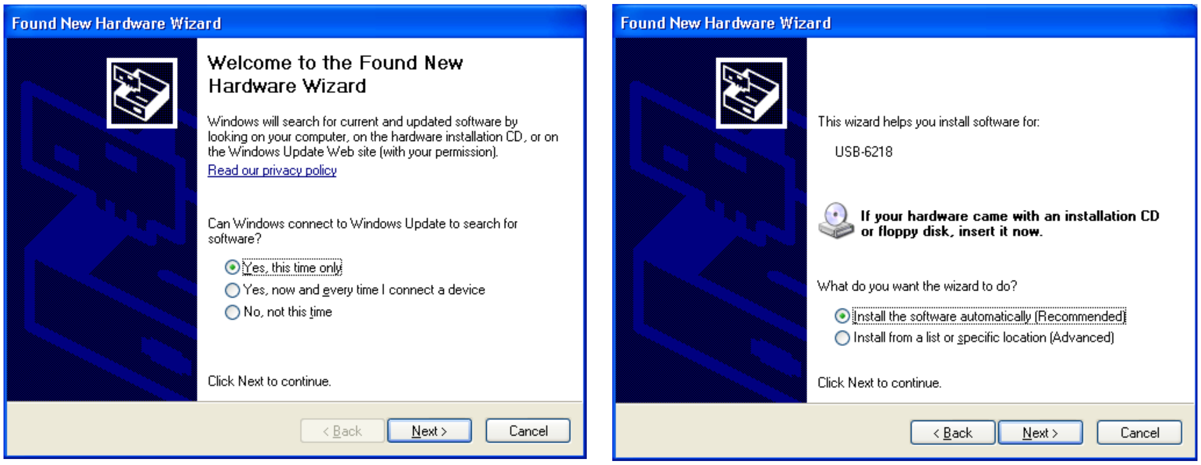
The wizard has finished installing the software for:

USB-621x Loader

Click Finish to close the wizard.

5. Now it repeats for the USB Device USB-6218.

Figure B-4. Found New Hardware Wizard Interface Repeated


Found New Hardware Wizard

Welcome to the Found New Hardware Wizard

Windows will search for current and updated software by looking on your computer, on the hardware installation CD, or on the Windows Update Web site (with your permission).

Read our privacy policy

Can Windows connect to Windows Update to search for software?

● Yes, this time only
○ Yes, now and every time I connect a device
○ No, not this time

Click Next to continue.

< Back
Next >
Cancel

Found New Hardware Wizard

This wizard helps you install software for:

USB-6218

If your hardware came with an installation CD or floppy disk, insert it now.

What do you want the wizard to do?

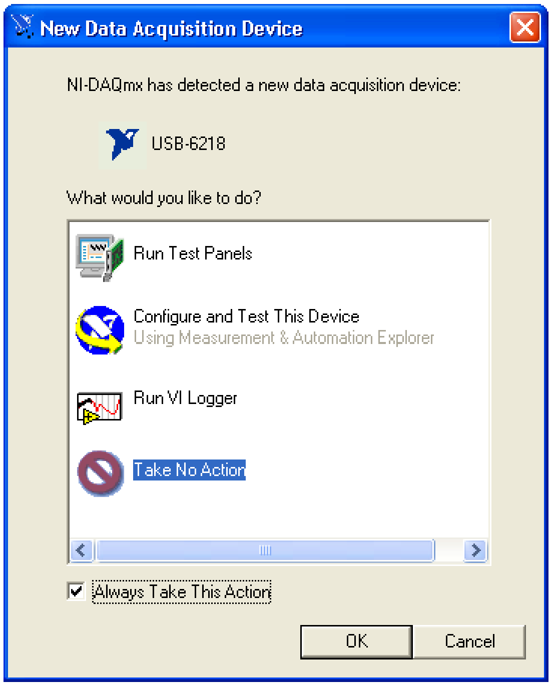
● Install the software automatically (Recommended)
○ Install from a list or specific location (Advanced)

Click Next to continue.

< Back
Next >
Cancel

6. Click **Next >, Next >,** then **Finish**. A message pops up that says the new hardware is installed and ready to use. Select **Take No Action**, and then check **Always Take This Action**.

Figure B-5. New Data Acquisition Device Interface


New Data Acquisition Device

NI-DAQmx has detected a new data acquisition device:

USB-6218

What would you like to do?

Run Test Panels
Configure and Test This Device
Using Measurement & Automation Explorer
Run VI Logger
Take No Action

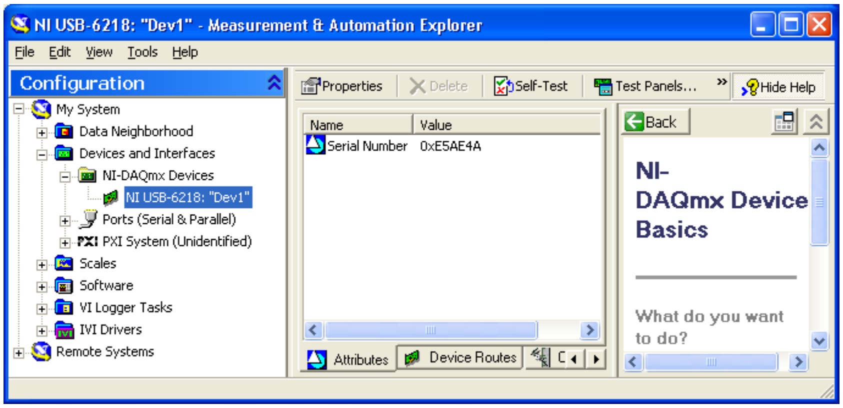
☑ Always Take This Action

OK
Cancel

Notes

- You will get two message sequences for EACH USB A-D device that you plug in and you will may get it again if you plug it into a different USB port, so it is simpler to plug into the same port each time. It seems to work fine either way.
- **Run Test Panels….** Setting the NI software to “Referenced Single Ended”: While it is not necessary for the **EVaRT** software to work, to get the correct looking signals on the Test Panels display, you need to set the **Analog Input > Input Configuration** to **RSE** (Referenced Single Ended). The **EVaRT** software sets this mode as part of its analog setup procedures, which is why it is not needed for **EVaRT** to work properly. Also, to have more than 8 channels displayed in the Test Panels (0-7), you must change this setting to **Referenced Single Ended** from its Differential Mode default.
- **EVaRT** starts numbering the analog channels starting at 1 whereas the Test Panels and chart (Table B-2 on page B-13) starts numbers at channel 0.

Figure B-6. NI USB-6218 Configuration Interface


NI USB-6218: "Dev1" - Measurement & Automation Explorer
File
Edit
View
Tools
Help
Configuration
My System
Data Neighborhood
Devices and Interfaces
NI-DAQmx Devices
NI USB-6218: "Dev1"
Ports (Serial & Parallel)
PXI System (Unidentified)
Scales
Software
VI Logger Tasks
IVI Drivers
Remote Systems
Properties
Delete
Self-Test
Test Panels...
Hide Help
Back
Attributes
Device Routes

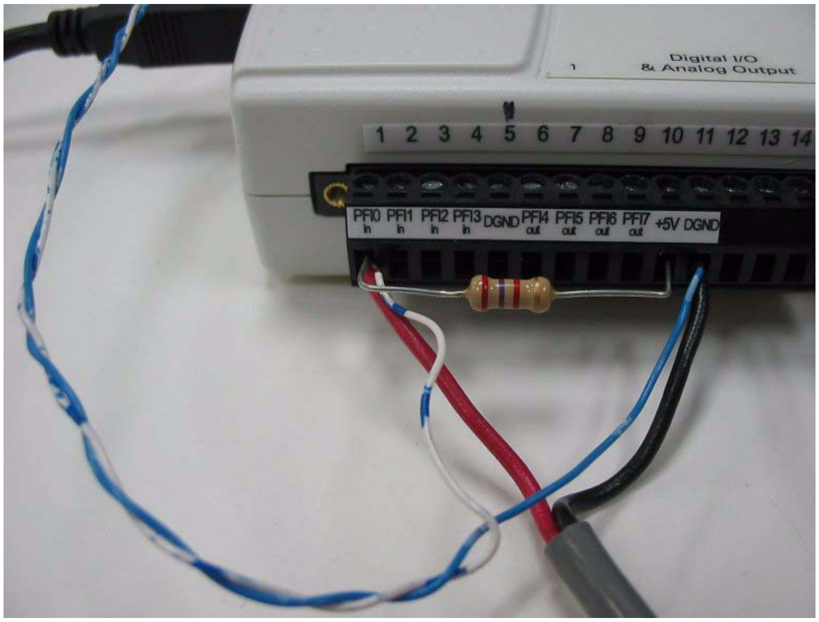
Name	Value
Serial Number	0xE5AE4A

NI-DAQmx Device Basics

What do you want to do?

Installing the Clock Wiring from the Master Camera

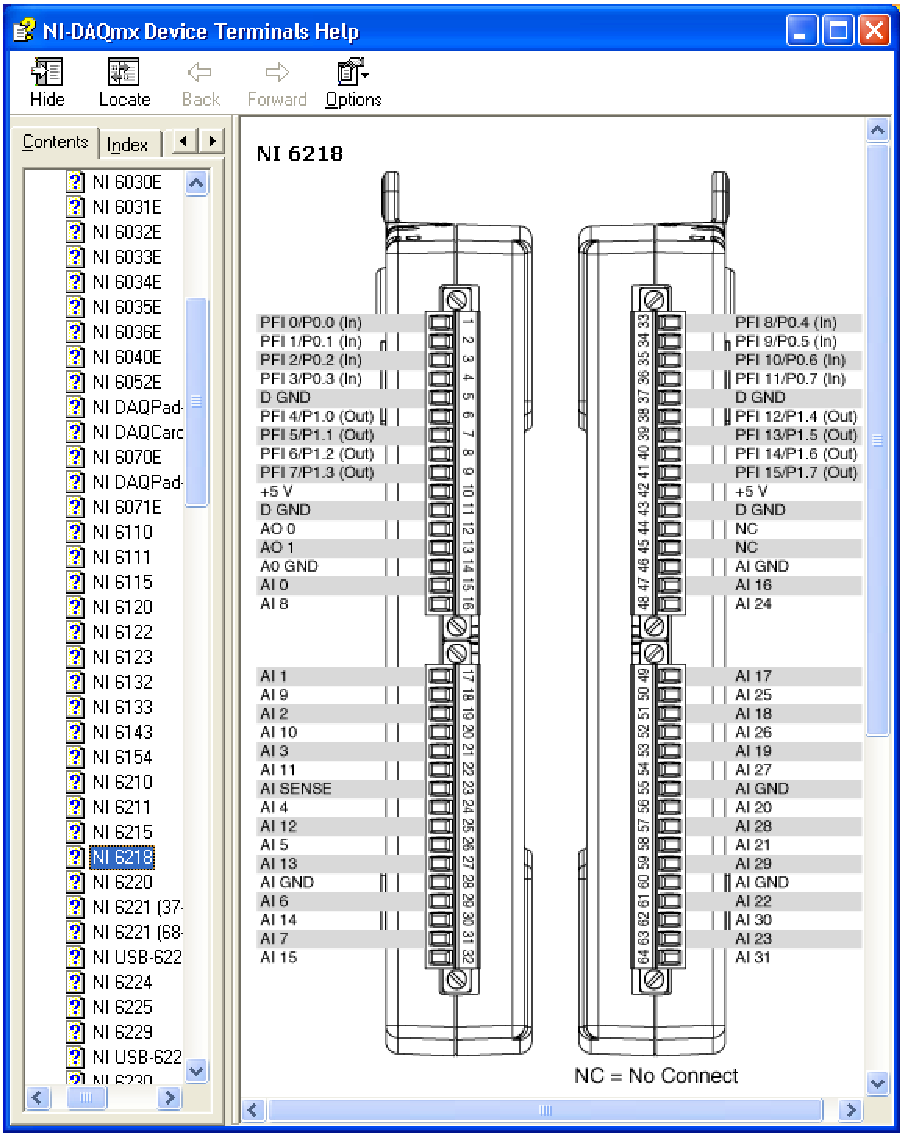
Figure B-7. Clock Wiring on Rear of NI USB-6218


1
Digital I/O
& Analog Output
1 2 3 4 5 6 7 8 9 10 11 12 13 14
PFI0 in
PFI1 in
PFI2 in
PFI3 in
DGND
PFI4 out
PFI5 out
PFI6 out
PFI7 out
+5V
DGND

- Master Camera Red (or white): Connects to Pin 1 (PFI0)
- Master Camera Black: Connects to Pin 11 (D GND)
- 2.7 kΩ Resistor connects from Pin 1 (PFI0) to Pin 10 (+5 V)

Note: NI USB-6259 uses PFI7 for clocking.

Figure B-8. NI USB-6218 Pinouts


NI-DAQmx Device Terminals Help
Hide
Locate
Back
Forward
Options
Contents
Index
NI 6030E
NI 6031E
NI 6032E
NI 6033E
NI 6034E
NI 6035E
NI 6036E
NI 6040E
NI 6052E
NI DAQPad
NI DAQCarc
NI 6070E
NI DAQPad
NI 6071E
NI 6110
NI 6111
NI 6115
NI 6120
NI 6122
NI 6123
NI 6132
NI 6133
NI 6143
NI 6154
NI 6210
NI 6211
NI 6215
NI 6218
NI 6220
NI 6221 (37
NI 6221 (68
NI USB-622
NI 6224
NI 6225
NI 6229
NI USB-622
NI 6230
NI 6218
PFI 0/P0.0 (In) 1
PFI 1/P0.1 (In) 2
PFI 2/P0.2 (In) 3
PFI 3/P0.3 (In) 4
D GND 5
PFI 4/P1.0 (Out) 6
PFI 5/P1.1 (Out) 7
PFI 6/P1.2 (Out) 8
PFI 7/P1.3 (Out) 9
+5 V 10
D GND 11
AO 0 12
AO 1 13
A0 GND 14
AI 0 15
AI 8 16
AI 1 17
AI 9 18
AI 2 19
AI 10 20
AI 3 21
AI 11 22
AI SENSE 23
AI 4 24
AI 12 25
AI 5 26
AI 13 27
AI GND 28
AI 6 29
AI 14 30
AI 7 31
AI 15 32
33 PFI 8/P0.4 (In)
34 PFI 9/P0.5 (In)
35 PFI 10/P0.6 (In)
36 PFI 11/P0.7 (In)
37 D GND
38 PFI 12/P1.4 (Out)
39 PFI 13/P1.5 (Out)
40 PFI 14/P1.6 (Out)
41 PFI 15/P1.7 (Out)
42 +5 V
43 D GND
44 NC
45 NC
46 AI GND
47 AI 16
48 AI 24
49 AI 17
50 AI 25
51 AI 18
52 AI 26
53 AI 19
54 AI 27
55 AI GND
56 AI 20
57 AI 28
58 AI 21
59 AI 29
60 AI GND
61 AI 22
62 AI 30
63 AI 23
64 AI 31
NC = No Connect

The USB device pinouts are available online after you install the device. To find them:

1. Launch **Measurement & Automation** which was installed when you installed the NIDAQ software.
2. Select **Devices and Interfaces**, then **NI-DAQmx Devices** and the page should appear as shown above.

Note: NI Numbering starts at Channel 0 where **EVaRT** channel numbering starts at 1. For example: AI 0 (above) corresponds to **EVaRT** Channel 1.

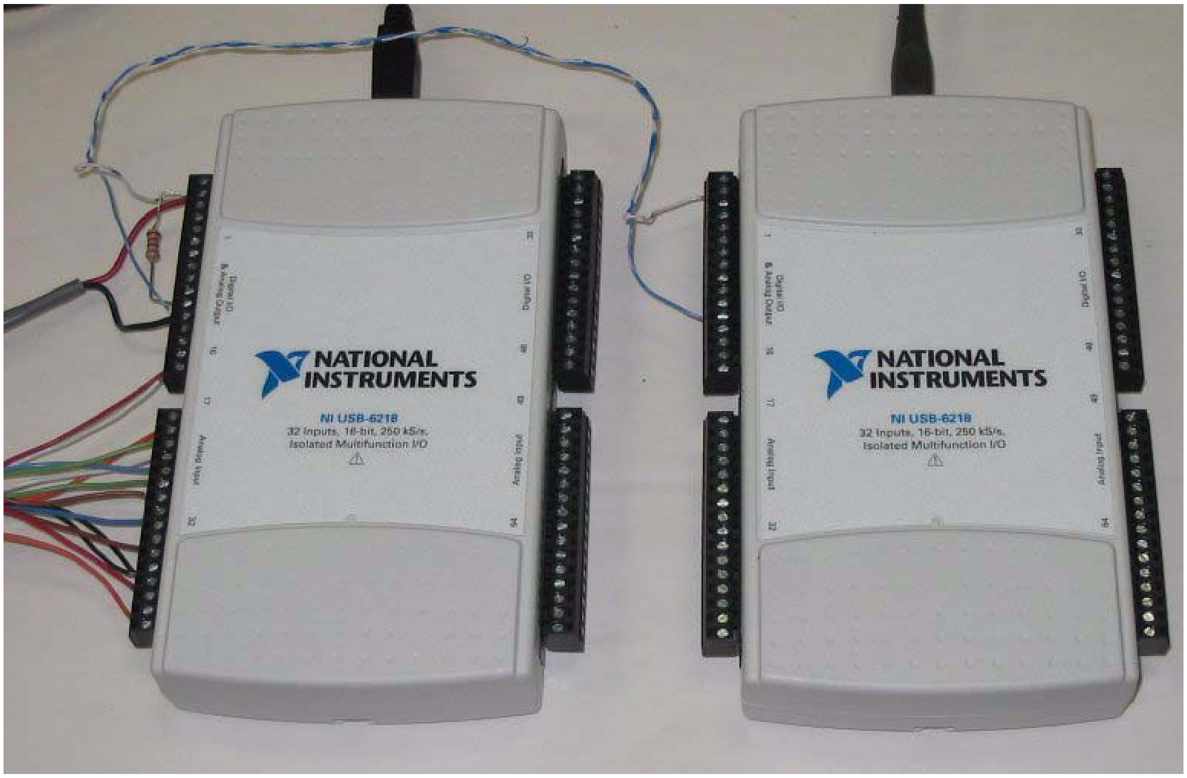
Which USB Device is Channels 1-32, which is 33-64?

The first device you plug in should be channels 1-32 in your **EVaRT** software. The second device should be channels 33-64 and so on for more devices. If you are not sure: When you connect to the Cameras in **EVaRT** 5.0.3 or later, the channel numbers (1-32) and the Serial Number of the USB device are reported in the dialog box. The Serial Number for the USB-6218 device is located on the bottom of the USB device.

Clock Wiring for Single and Multiple USB Devices

Eagle and Hawk cameras require a 2.7 kΩ pull-up resistor from +5 Volts to the PFI-0 pin as shown

Figure B-9. Clock Wiring for Mutiple Devices


NATIONAL INSTRUMENTS
NI USB-6218
32 Inputs, 16-bit, 250 kS/s, Isolated Multifunction I/O
NATIONAL INSTRUMENTS
NI USB-6218
32 Inputs, 16-bit, 250 kS/s, Isolated Multifunction I/O

A Single Pull-up resistor with a 2.7 kΩ (or close) value will work for connecting up to 6 USB devices together as shown below. You need only to connect PFI0 and D GND signals in parallel for clocking the multiple USB Devices. A single pull-up resistor works for all devices.

USB 2.0 Cable Lengths

The USB-6218 comes with a one meter USB cable. It has been tested with longer USB cable lengths up to 16 ft. (5 meters) and it works well with either and any mix of cables.

USB Expansion Ports

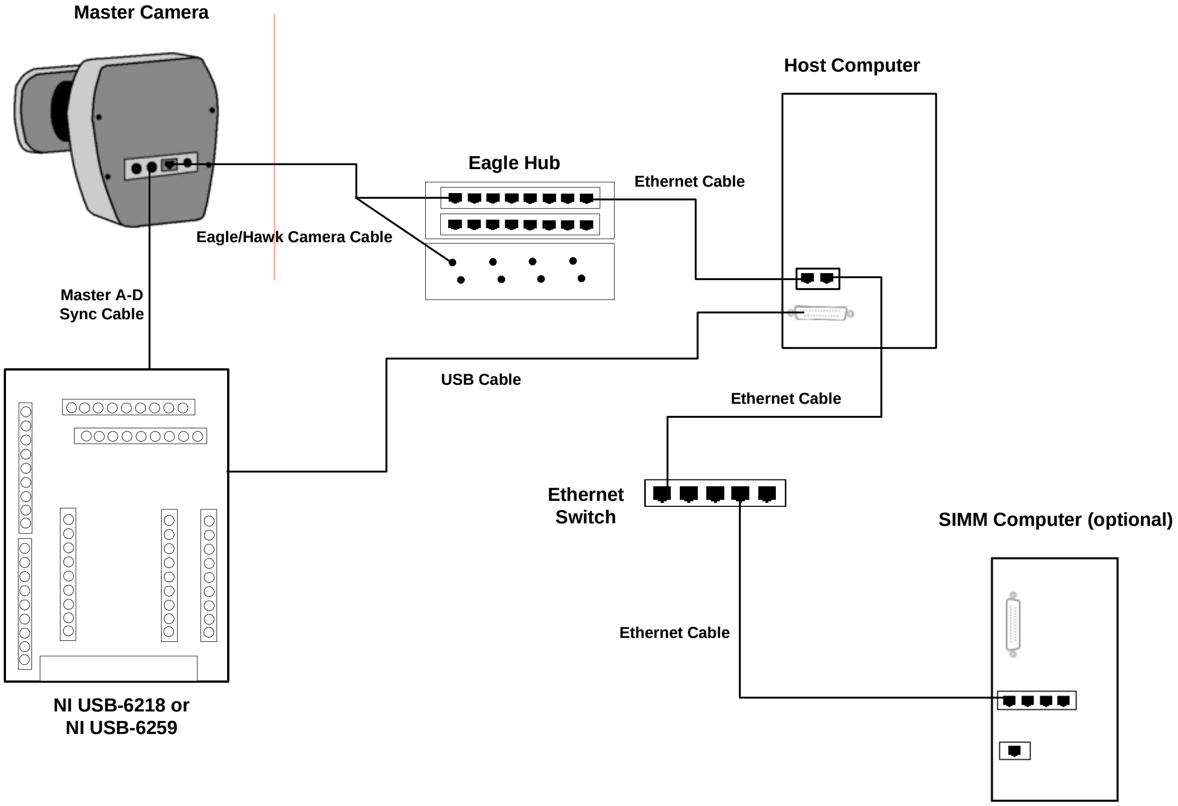
Internal or External USB Expansion devices also have been tested and appear to work well without problems. This allows you use a single USB port on the main capture computer and plug in as many USB devices as needed.

Table B-2. Analog Input Channel Connections and Master Camera Clocking (NI USB-6218)

Screw Terminal #	EVaRT Channel #	Setup Name	Screw Terminal #	EVaRT Channel #	Setup Name
1	CH 1		49	CH 21	
2	CH 9		50	CH 29	
3	AI GROUND		51	AI GROUND	
4	CH 2		52	CH 22	
5	CH 10		53	CH 30	
6	AI GROUND		54	AI GROUND	
7	CH 3		55	CH 23	
8	CH 11		56	CH 31	
9	AI GROUND		57	AI GROUND	
10	CH 4		58	CH 24	
11	CH 12		59	CH 32	
12	AI GROUND		60	AI GROUND	
13	NOT USED		61	NOT USED	
14	AI GROUND		62	AI GROUND	
15	NOT USED		63	NOT USED	
16	NOT USED		64	NOT USED	
17	CH 5		65	NOT USED	
18	CH 13		66	NOT USED	
19	AI GROUND		67	NOT USED	
20	CH 6		68	NOT USED	
21	CH 14		69	NOT USED	
22	AI GROUND		70	NOT USED	
23	CH 7		71	NOT USED	
24	CH 15		72	NOT USED	
25	AI GROUND		73	PFI 0	Jumper Cable
26	CH 8		74	PFI 1	
27	CH 16		75	PFI 2	
28	NOT USED		76	PFI 3	
29	NOT USED		77	PFI 4	
30	AI GROUND		78	PFI 5	
31	NOT USED		79	PFI 6	
32	NOT USED		80	PFI 7	4.7 kΩ Resistor & A/D Sync Cable & Jumper Cable
33	CH 17		81	PFI 8	
34	CH 25		82	D GROUND	
35	AI GROUND		83	PFI 9	
36	CH 18		84	D GROUND	
37	CH 26		85	PFI 10	
38	AI GROUND		86	D GROUND	
39	CH 19		87	PFI 11	
40	CH 27		88	D GROUND	
41	AI GROUND		89	PFI 12	
42	CH 20		90	D GROUND	A/D Sync Ground
43	CH 28		91	PFI 13	
44	AI GROUND		92	D GROUND	
45	NOT USED		93	PFI 14	
46	AI GROUND		94	D GROUND	
47	NOT USED		95	PFI 15	
48	AI GROUND		96	+5 V	4.7 kΩ Resistor

64-Channel SCB-100 and NI PCI-6071E Configuration

Figure B-10. Digital Camera System and SCB-100/NI PCI-6071 Hardware Setup


Master Camera
Host Computer
Eagle Hub
Ethernet Cable
Eagle/Hawk Camera Cable
Master A-D
Sync Cable
USB Cable
Ethernet Cable
Ethernet
Switch
SIMM Computer (optional)
Ethernet Cable
NI USB-6218 or
NI USB-6259

Important

1. Channels are numbered 1 through 64 in the **EVaRT Setup > Analog** panel, whereas the manufacturer of the analog board, **National Instruments**, uses channel numbers 0-63.
2. Channels which are marked as **NOT USED** should not be connected to any external circuitry or damage or malfunction may result.
3. If you are using an optional second PCI-6071E (for up to 128 channels), you need to have the Master A-D Sync cable connected to both cards. Only one 4.7 k-ohm resistor is required to be installed into both PCI-6071E units.

Figure B-11. Master Camera Connections (SCB-100 and PCI-6071E A-D Card)

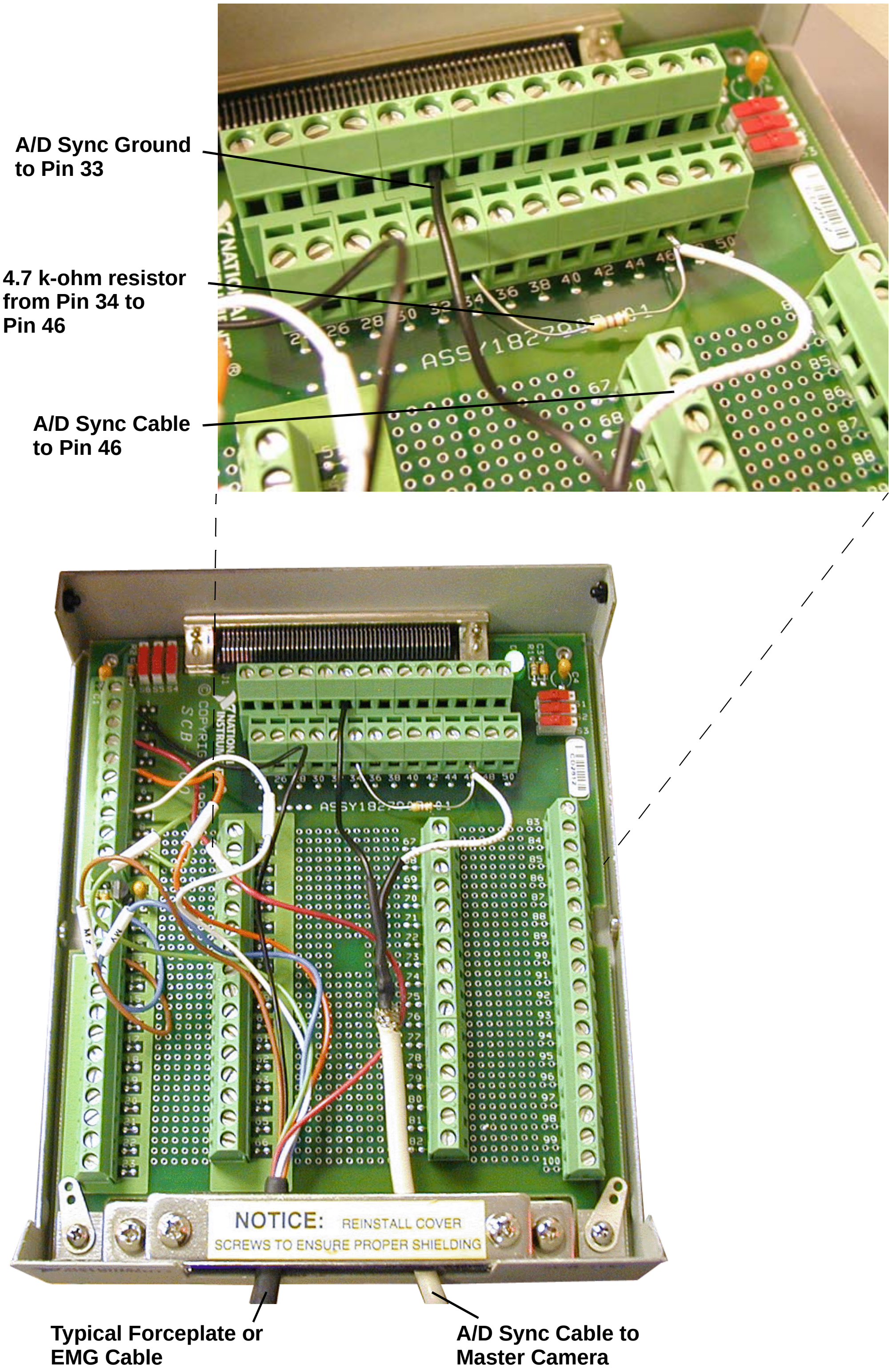

A/D Sync Ground to Pin 33
4.7 k-ohm resistor from Pin 34 to Pin 46
A/D Sync Cable to Pin 46
NOTICE: REINSTALL COVER SCREWS TO ENSURE PROPER SHIELDING
Typical Forceplate or EMG Cable
A/D Sync Cable to Master Camera

Table B-3. Analog Input Channel Connections for SCB-100 Used with PIC-6071E A-D Card

Screw Terminal #	Channel #	Setup Name	Screw Terminal #	Channel #	Setup Name
1	GROUND		51	CH 17	
2	GROUND		52	CH 25	
3	CH 1		53	CH 18	
4	CH 9		54	CH 26	
5	CH 2		55	CH 19	
6	CH 10		56	CH 27	
7	CH 3		57	CH 20	
8	CH 11		58	CH 28	
9	CH 4		59	CH 21	
10	CH 12		60	CH 29	
11	CH 5		61	CH 22	
12	CH 13		62	CH 30	
13	CH 6		63	CH 23	
14	CH 14		64	CH 31	
15	CH 7		65	CH 24	
16	CH 15		66	CH 32	
17	CH 8		67	CH 33	
18	CH 16		68	CH 41	
19	NOT USED		69	CH 34	
20	NOT USED		70	CH 42	
41	NOT USED		71	CH 35	
22	NOT USED		72	CH 43	
23	NOT USED		73	CH 36	
24	NOT USED		74	CH 44	
25	NOT USED		75	NOT USED	
26	NOT USED		76	GROUND	
27	NOT USED		77	CH 37	
28	NOT USED		78	CH 45	
29	NOT USED		79	CH 38	
30	NOT USED		80	CH 46	
31	NOT USED		81	CH 39	
32	NOT USED		82	CH 47	
33	GROUND	A/D Sync Ground wire	83	CH 40	
34	+5 V	4.7 kΩ Resistor, End A	84	CH 48	
35	NOT USED		85	CH 49	
36	NOT USED		86	CH 57	
37	NOT USED		87	CH 50	
38	NOT USED		88	CH 58	
39	NOT USED		89	CH 51	
40	NOT USED		90	CH 59	
41	NOT USED		91	CH 52	
42	NOT USED		92	CH 60	
43	NOT USED		93	CH 53	
44	NOT USED		94	CH 61	
45	NOT USED		95	CH 54	
46	PF17 StarScan	4.7 kΩ Resistor and A/D Sync Cable	96	CH 62	
47	NOT USED		97	CH 55	
48	NOT USED		98	CH 63	
49	NOT USED		99	CH 56	
50	NOT USED		100	CH 64	

Table B-4. Typical Connections For 2 AMTI Forceplates and 10 EMG Channels for SCB-100

Screw Terminal #	Channel #	Setup Name	Screw Terminal #	Channel #	Setup Name
1	GROUND	Forceplate Grounds	51	CH 17	EMG05
2	GROUND	EMG Grounds	52	CH 25	
3	CH 1	F1X	53	CH 18	EMG06
4	CH 9	F2Z	54	CH 26	
5	CH 2	F1Y	55	CH 19	EMG07
6	CH 10	M2X	56	CH 27	
7	CH 3	F1Z	57	CH 20	EMG08
8	CH 11	M2Y	58	CH 28	
9	CH 4	M1X	59	CH 21	EMG09
10	CH 12	M2Z	60	CH 29	
11	CH 5	M1Y	61	CH 22	EMG10
12	CH 13	EMG01	62	CH 30	
13	CH 6	M1Z	63	CH 23	
14	CH 14	EMG02	64	CH 31	
15	CH 7	F2X	65	CH 24	
16	CH 15	EMG03	66	CH 32	
17	CH 8	F2Y	67	CH 33	
18	CH 16	EMG04	68	CH 41	
19	NOT USED		69	CH 34	
20	NOT USED		70	CH 42	
41	NOT USED		71	CH 35	
22	NOT USED		72	CH 43	
23	NOT USED		73	CH 36	
24	NOT USED		74	CH 44	
25	NOT USED		75	NOT USED	
26	NOT USED		76	GROUND	
27	NOT USED		77	CH 37	
28	NOT USED		78	CH 45	
29	NOT USED		79	CH 38	
30	NOT USED		80	CH 46	
31	NOT USED		81	CH 39	
32	NOT USED		82	CH 47	
33	GROUND	A/D Sync Ground wire	83	CH 40	
34	+5 V	4.7 kΩ Resistor, End A	84	CH 48	
35	NOT USED		85	CH 49	
36	NOT USED		86	CH 57	
37	NOT USED		87	CH 50	
38	NOT USED		88	CH 58	
39	NOT USED		89	CH 51	
40	NOT USED		90	CH 59	
41	NOT USED		91	CH 52	
42	NOT USED		92	CH 60	
43	NOT USED		93	CH 53	
44	NOT USED		94	CH 61	
45	NOT USED		95	CH 54	
46	PF17 StarScan	4.7 kΩ Resistor and A/D Sync Cable	96	CH 62	
47	NOT USED		97	CH 55	
48	NOT USED		98	CH 63	
49	NOT USED		99	CH 56	
50	NOT USED		100	CH 64	

Note: A-D interconnect schemes will be similar for different analog configurations.

Table B-5. Analog Input Channel Connections for Midas-Based Camera Systems (with the SCB-100 A-D Interconnect Box and PCI-6071E A-D Card)

Screw Terminal #	Channel #	Setup Name	Screw Terminal #	Channel #	Setup Name
1	GROUND		51	CH 17	
2	GROUND		52	CH 25	
3	CH 1		53	CH 18	
4	CH 9		54	CH 26	
5	CH 2		55	CH 19	
6	CH 10		56	CH 27	
7	CH 3		57	CH 20	
8	CH 11		58	CH 28	
9	CH 4		59	CH 21	
10	CH 12		60	CH 29	
11	CH 5		61	CH 22	
12	CH 13		62	CH 30	
13	CH 6		63	CH 23	
14	CH 14		64	CH 31	
15	CH 7		65	CH 24	
16	CH 15		66	CH 32	
17	CH 8		67	CH 33	
18	CH 16		68	CH 41	
19	NOT USED		69	CH 34	
20	NOT USED		70	CH 42	
41	NOT USED		71	CH 35	
22	NOT USED		72	CH 43	
23	NOT USED		73	CH 36	
24	NOT USED		74	CH 44	
25	NOT USED		75	NOT USED	
26	NOT USED		76	GROUND	
27	NOT USED		77	CH 37	
28	NOT USED		78	CH 45	
29	NOT USED		79	CH 38	
30	NOT USED		80	CH 46	
31	NOT USED		81	CH 39	
32	NOT USED		82	CH 47	
33	NOT USED		83	CH 40	
34	NOT USED		84	CH 48	
35	NOT USED		85	CH 49	
36	NOT USED		86	CH 57	
37	NOT USED		87	CH 50	
38	PFI0/TRIG1	Red trigger wire	88	CH 58	
39	NOT USED		89	CH 51	
40	NOT USED		90	CH 59	
41	NOT USED		91	CH 52	
42	NOT USED		92	CH 60	
43	NOT USED		93	CH 53	
44	NOT USED		94	CH 61	
45	NOT USED		95	CH 54	
46	NOT USED		96	CH 62	
47	NOT USED		97	CH 55	
48	NOT USED		98	CH 63	
49	NOT USED		99	CH 56	
50	NOT USED		100	CH 64	

Table B-6. Typical Connections For 2 AMTI Forceplates and 10 EMG Channels for Midas-Based Camera Systems (with SCB-100 and PCI-6071E A-D Card)

Screw Terminal #	Channel #	Setup Name	Screw Terminal #	Channel #	Setup Name
1	GROUND	Forceplate Grounds	51	CH 17	EMG05
2	GROUND	EMG Grounds	52	CH 25	
3	CH 1	F1X	53	CH 18	EMG06
4	CH 9	F2Z	54	CH 26	
5	CH 2	F1Y	55	CH 19	EMG07
6	CH 10	M2X	56	CH 27	
7	CH 3	F1Z	57	CH 20	EMG08
8	CH 11	M2Y	58	CH 28	
9	CH 4	M1X	59	CH 21	EMG09
10	CH 12	M2Z	60	CH 29	
11	CH 5	M1Y	61	CH 22	EMG10
12	CH 13	EMG01	62	CH 30	
13	CH 6	M1Z	63	CH 23	
14	CH 14	EMG02	64	CH 31	
15	CH 7	F2X	65	CH 24	
16	CH 15	EMG03	66	CH 32	
17	CH 8	F2Y	67	CH 33	
18	CH 16	EMG04	68	CH 41	
19	NOT USED		69	CH 34	
20	NOT USED		70	CH 42	
41	NOT USED		71	CH 35	
22	NOT USED		72	CH 43	
23	NOT USED		73	CH 36	
24	NOT USED		74	CH 44	
25	NOT USED		75	NOT USED	
26	NOT USED		76	GROUND	
27	NOT USED		77	CH 37	
28	NOT USED		78	CH 45	
29	NOT USED		79	CH 38	
30	NOT USED		80	CH 46	
31	NOT USED		81	CH 39	
32	NOT USED		82	CH 47	
33	NOT USED		83	CH 40	
34	NOT USED		84	CH 48	
35	NOT USED		85	CH 49	
36	NOT USED		86	CH 57	
37	NOT USED		87	CH 50	
38	PFI0/TRIG1	Red trigger wire	88	CH 58	
39	NOT USED		89	CH 51	
40	NOT USED		90	CH 59	
41	NOT USED		91	CH 52	
42	NOT USED		92	CH 60	
43	NOT USED		93	CH 53	
44	NOT USED		94	CH 61	
45	NOT USED		95	CH 54	
46	NOT USED		96	CH 62	
47	NOT USED		97	CH 55	
48	NOT USED		98	CH 63	
49	NOT USED		99	CH 56	
50	NOT USED		100	CH 64	

Appendix C Marker Sets

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Overview

When deciding how to place markers for **EVaRT,** it is important to realize that asymmetry is used by the software to distinguish left from right on the subject. Therefore, thigh markers may not be placed symmetrically, left to right, and a single marker might be placed on one shoulder to distinguish left from right.

Also, asymmetry is used to distinguish 3 markers linked together in a triangle. Therefore, the hand and thumb marker should not be the same distance from the wrist marker and should be well separated.

Another limit is the actual number of markers used. For a very detailed skeleton, you may be tempted to use a large number of markers. However, since each marker requires computation time, there is a practical limit to the number of markers used before the speed of real-time tracking is impacted.

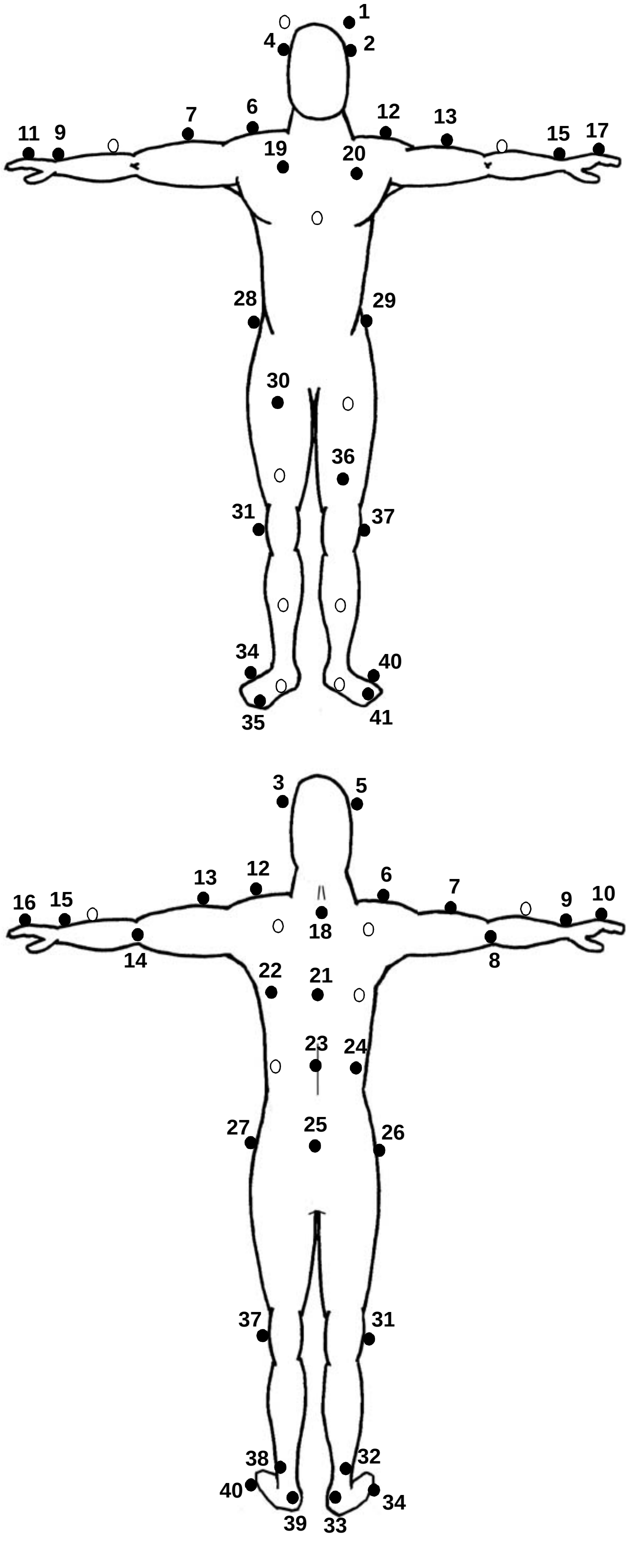
Specific examples of marker sets suited for both animation and biomechanics are given in the following figures.

Animation

Figure C-1 is an example of a typical marker set using 35 markers. This example also shows suggested naming conventions. However, naming conventions that best suit your needs should be used.

Note: Biceps and thigh markers are intentionally placed asymmetrically to help the template distinguish left and right more easily.

Figure C-1. Typical Animation Marker Set


1
4
2
7
6
12
13
11
9
15
17
19
20
28
29
30
36
31
37
34
40
35
41
3
5
13
12
6
7
16
15
9
10
18
14
8
22
21
23
24
27
25
26
37
31
38
32
40
34
39
33

Note-When placing markers on end segments, the markers should not form a line and should not have mirror symmetry. Thus, thumb and hand markers should never be the same distance from the wrist marker and should be well separated.

1 - TopHead
2 - LFrontHead
3 - LRearHead
4 - RFrontHead
5 - RRearHead
6 - RShoulder
7 - RBicep
8 - RElbow
9 - RWrist
10 - RPinky
11 - RThumb
12 - LShoulder
13 - LBicep
14 - LElbow
15 - LWrist
16 - LPinky
17 - LThumb
18 - TopSpine
19 - RFrontShoulder
20 - LFrontShoulder
21 - MidBack
22 - LShoulderOffset
23 - LowBack
24 - RRootOffset
25 - Root
26 - RRearHip
27 - LRearHip
28 - RFrontHip
29 - LFrontHip
30 - RThigh
31 - RKnee
32 - RAnkle
33 - RHeel
34 - RMidFoot
35 - RToe
36 - LThigh
37 - LKnee
38 - LAnkle
39 - LHeel
40 - LMidFoot
41 - LToe

Biomechanics

When using **EVaRT** in biomechanics applications such as **OrthoTrak**, the standard **Helen Hayes** marker set must be modified by adding one additional marker to either the left or right scapula. Also, new linkages must be added. This will give the asymmetry required so that the dynamic template can distinguish left from right.

In addition, the order of markers is important in real-time since the order in the list determines how quickly the software can establish marker identity using the dynamic template. In general, the marker list should start with the topmost marker. Proceed down the trunk of the figure, and then down each extremity.

For example, if head markers are used, they should be at the top of the list. If no head markers are used, the shoulder and pelvis markers should be at the top of the list.

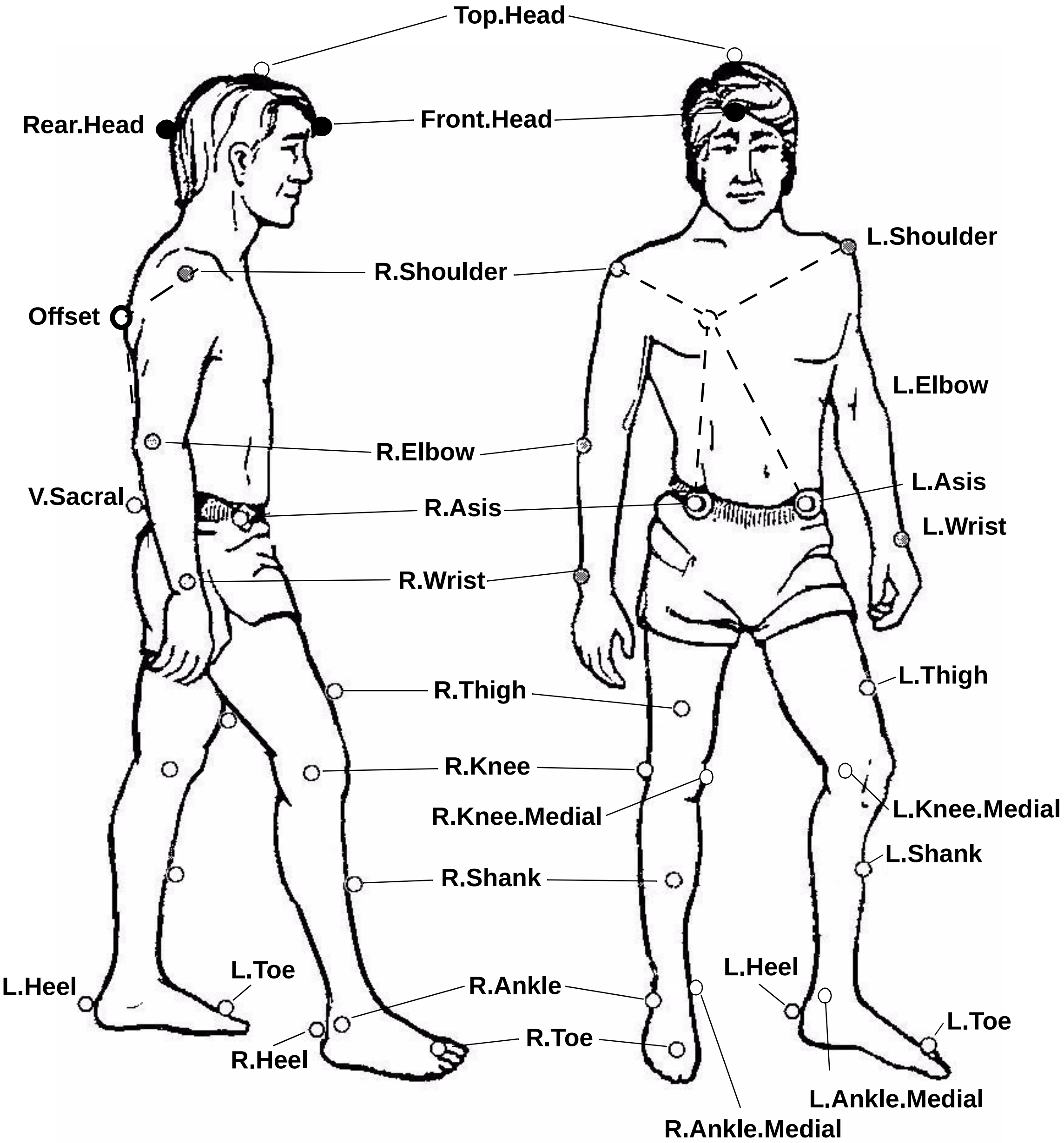
The recommended procedure is as follows:

Within EVaRT

1. Launch **EVaRT** and click on the **Connect** button.
2. Create a template with the modified marker set and save the results in the project file. For building a template, refer to “Building a Template” on page 9-5.

You now have a template that can be used to automatically identify markers in real-time with this subject. When you click on the **Run** button and the subject enters the capture volume and all markers are visible, the linkages to the markers will appear automatically, indicating that the markers are properly identified.

Figure C-2. Helen Hayes Marker Set Marker Placement


Top.Head
Rear.Head
Front.Head
L.Shoulder
R.Shoulder
Offset
L.Elbow
R.Elbow
V.Sacral
L.Asis
R.Asis
L.Wrist
R.Wrist
L.Thigh
R.Thigh
R.Knee
R.Knee.Medial
L.Knee.Medial
L.Shank
R.Shank
L.Heel
L.Toe
R.Ankle
L.Heel
L.Toe
R.Toe
R.Heel
L.Ankle.Medial
R.Ankle.Medial

Examples

Refer to the sample project folders in the **C:\ProgramFiles\MotionAnalysis\EVaRT50\Samples** directory, which includes complete marker sets.

Developing Optimum Markers Sets

It has always been very tempting to anyone in the world of motion capture to get one “optimum” marker set. But typically, even the best animators and researchers use flexible marker setups, altering the marker sets to fit their desired capture goals.

If you are set on developing an optimal marker set, there are several things to take into consideration when you are trying to develop this.

1. What kind of movements are you doing?
    - Is there going to be a lot of bending at the waist? If so, then front hip markers are probably not good choice to use.
    - Are you going to be doing a lot of movements like rolling on the floor or sitting in a chair or laying down? If so, consider how you have markers on the back, since they will be obscured a lot.
    - Are you crouching a lot? If so, markers on the front of the body (chest) might be a bad idea.
2. Camera placement: Are you using a single camera placement scenario (that is will you move your cameras around)?
    - If yes, then you have more flexibility with a single, “optimal” marker set.
    - If no, then you have to take the issues listed in (1) above into consideration. Especially in regards to the movements where the markers are blocked by your subject’s body.
3. Optimal number of markers: A general rule is that if you want a full 6-DOF set of information for each segment, you must have a minimum of 3 markers per segment. Currently we can shortcut that by allowing markers to be shared across joints (like the knees, ankles and elbows). Also, consider the Join Virtual definitions, to get good quality Join Virtual definitions, you want to have enough markers on the segment so that you can reconstruct missing markers using markers on that same segment. Typically in this case 4 markers per segment is advantageous.An example would be to place markers on the upper arm in the following positions: Shoulder, bicep, tricep and elbow.
4. Landmarking: Markers should be positioned, when possible, on bony landmarks. A bony landmark is an area like your ankle malleolus, elbow, knee condyles, wrist bones etc. This avoid the undo influence of soft tissue movements which can lead to noise in the marker positions.
5. Between people, the markers don't have to be in exactly in the same position. But a close approximation to the different sizes of people is required, especially if you are planning on using the PoseID-autofit option.

    If you don't care about using the PoseID-autofit option, then you can place the markers anyway you like.

Appendix D Capturing Facial Motion

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Marker Placement	D-4
Building a Face Template	D-5
Examples	D-7
Facial Animation Techniques for Motion Capture	D-9

Overview

The **EVaRT** system can also be used to capture the fine nuances of human facial motions. Three to six cameras, positioned up to 30 degrees apart around a relatively stationary subject, will provide sufficient coverage. The motion of 4 mm reflective markers, strategically placed about the subject's face, is captured and 3D translation data provides manipulation to an animated character's face model.

Animation programs like **SoftImage**, **Maya (Alias)**, **Motionbuilder**, and **3D Studio Max** will currently accept this data.

System Configuration and Setup

In order to use the **EVaRT** system for facial motion capture, some additional equipment is required. This is known as the Facial Motion Capture Accessory Kit, and it contains a Calibration Square, a facial marker set with glue, a mirror, and tweezers. The Facial Calibration Square is included with this User's Manual.

The longer focal length lenses allow positioning of the cameras an appropriate distance from the subject, resulting in ring light illumination that is evenly distributed across the field of view. The cameras should be positioned on a subject wearing the reflective markers.

The goals of camera placement are:

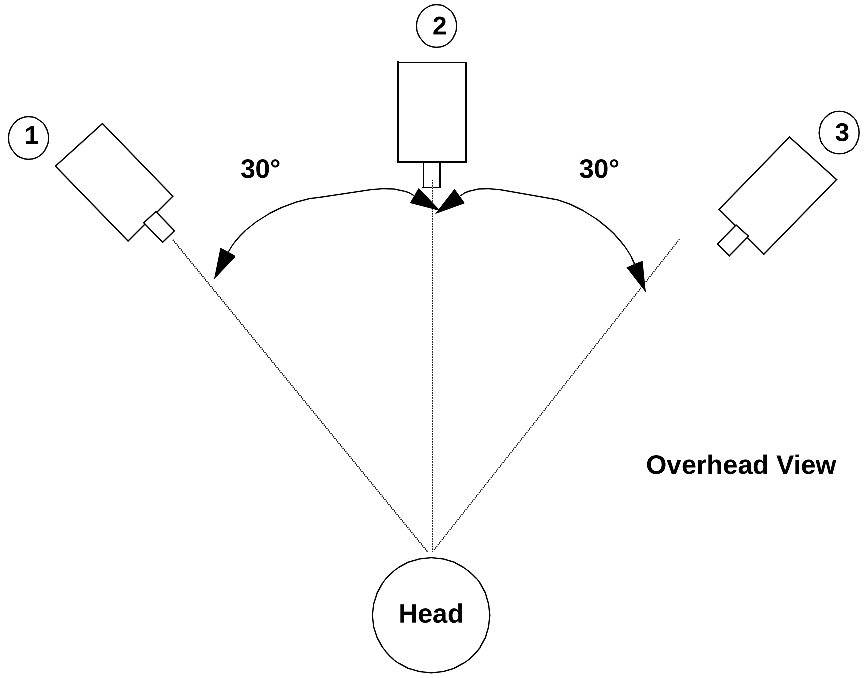
- Have at least 3 cameras see as many markers as possible. When 3 or more cameras see a marker, the chance of a ghost marker occurring is minimal.
- Minimize the merging of markers and marker dropout in the camera views. Both are undesirable.

- Maximize and balance angular displacement between cameras by having at least 30 degrees of angular displacement between the cameras. The exception is the lower camera (see Figure D-1).
- Optimize what each camera sees by ensuring that each field-of-view is filled with as many markers as possible.

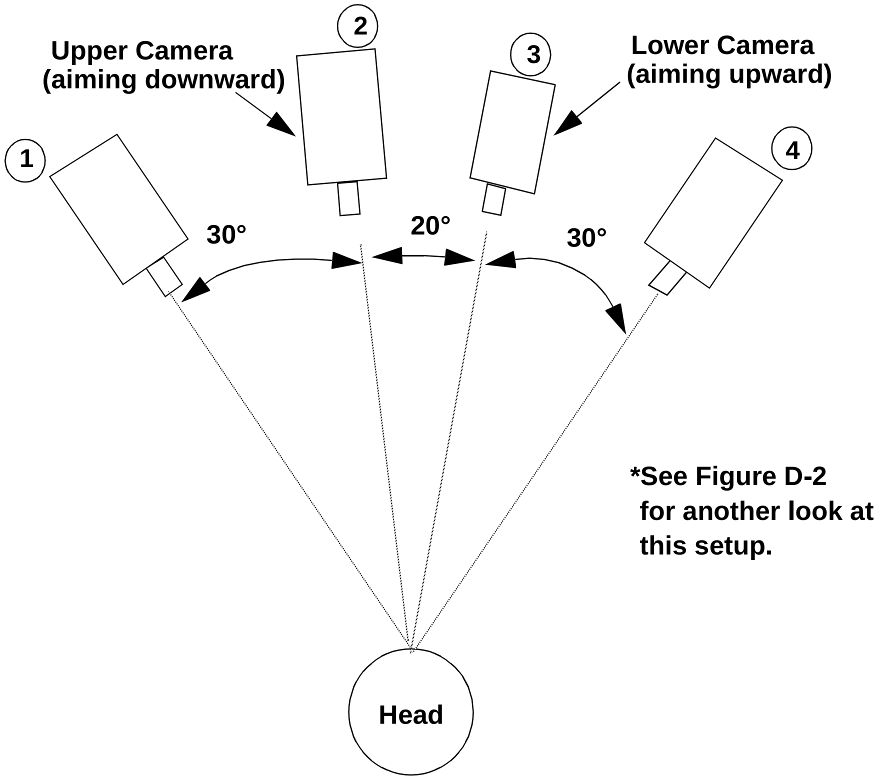
1. Start by setting up the cameras as shown in Figure D-2 on page D-4.
2. Have the subject sit comfortably on a stool or chair facing the camera array.
3. Optimize the subject-to-camera distance by ensuring that markers fill the field of view, but are not outside the field of view.
4. Have the subject open their mouth wide, and make sure the head and chin markers stay in view. Look for potential merging between markers. This can especially be a problem around the lips.
5. With the camera positions optimized, place tape on the floor marking where the legs of the stool or chair are located.
6. Attach the Facial Calibration Square to the light stand and position it next to the subject. With the subject still sitting, adjust the height of the light stand until the square is positioned at the same height as the subject's head.
7. Remove the subject and stool from the capture zone and position the Calibration Square within this zone. The square is now located where the subject's head was located.
8. Adjust the square's position so each camera sees as many calibration markers as possible. Remember that the subjects's face will be within this calibrated space during motion capture. Mark the floor with tape where the feet of the light stand are positioned. This will facilitate quick recalibration if it becomes necessary.
9. As an alternative, you may put the Facial Calibration Square against a wall, calibrate, and then capture as long as the subjects face is within 1 foot of the Facial Calibration Square.

Figure D-1. Three and Four Camera Facial Motion Capture Setup

Note—This setup is given as a minimum for the required setup.


2
1
3
30°
30°
Overhead View
Head

***4-Camera Facial Motion Capture Setup**


2
Upper Camera
(aiming downward)
3
Lower Camera
(aiming upward)
1
4
30°
20°
30°
*See Figure D-2
for another look at
this setup.
Head

Marker Placement

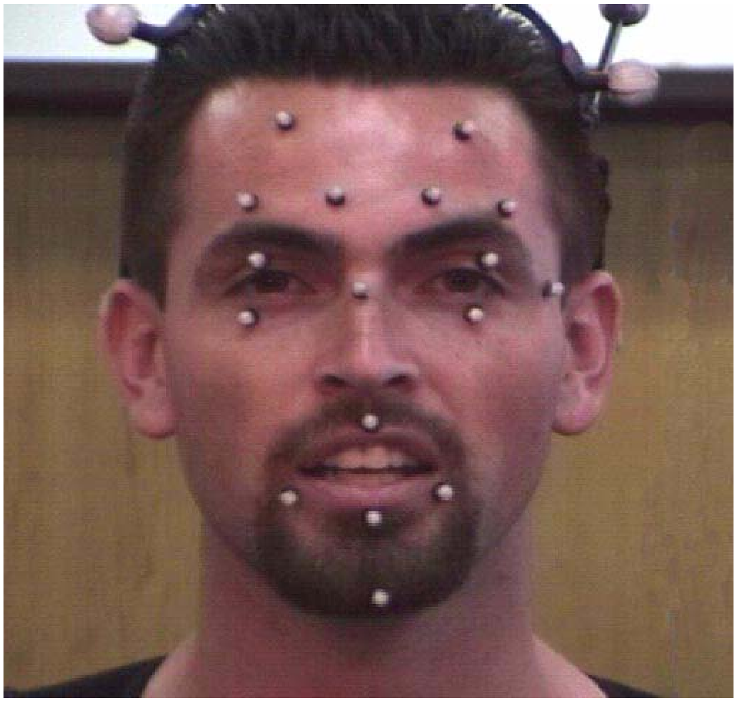
The number and placement of markers for facial motion capture is dependent on the animation character's face model, and the animation software used to apply motion to the model. If a human face is to be animated, the markers should be placed at the major motion points on the face. If the face of a non-human character is to be animated, markers will be placed where the facial characteristics unique to that character will be accentuated.

In most cases, general areas of the face will need to be marked and captured. The following are suggested marker placements for facial motion capture:

Head

Three markers are used to identify head movements. If possible, the markers should be placed on areas with little or no skin movement. A tight fitting skull-cap may be used for attaching markers to the head. One marker should be placed on top of the head and one on each side of the head. These three markers are used to calculate the center of the head, which is the point from where all other marker translations are calculated.

Figure D-2. Marker Set for Facial Motion Capture



Eyebrows

One to three markers per eyebrow are used to track eyebrow movements. The exact position of markers on or around the eyebrows depends upon the subject's face.

Nose Bridge	Place one marker between the eyes, on the upper bridge of the nose. This area tends to be a junction point between the different regions of the face.
Eyelids	Both the top and bottom eyelids may be marked; however, you can expect some optical interference from the eyelashes, which can add more time to tracking and editing. Also, if the bottom eyelids are marked, these markers should be offset from the position of top eyelid markers to minimize marker merging.
Nose	The nose has relatively little motion except for the nostril. If nostril flaring is of interest, attach a marker to each nostril.
Cheeks	At least one marker should be placed on each cheek. Exact location will depend on the animation character model and the facial features of the subject.
Lips	The lips usually have the greatest amount of movement on the face. From 4 to 9 markers can be used to capture lip movement. Markers on the top lip should be offset from markers on the bottom lip to minimize merging. Also, areas around the lips can be marked to provide motion transitions.
Chin	One to three markers can be attached to capture chin motion.
Jaw	Attach one or more markers along the jawbone for jaw motion. This is very important for lip syncing.

Building a Face Template

1. Choose **Motion Capture** from the Mode Buttons.
2. Choose **Output** from the sub-panel buttons.
3. Check the Tracked Binary (TRB or TRC) check box on the Output sub-panel.
4. Type a file name in the name box and press **Enter**.
5. Set the Duration (seconds) to **10**.
6. Collect motion data of the subject by having the person stand in the middle of the capture volume.
7. Click **Record** on the Output sub-panel.
8. The subject must stay in an initial frozen position for three to five seconds.
9. After staying frozen in this initial position for up to five seconds, the person must move through a complete range of facial motion that exhibits the full extent of stretch that will be experienced during subsequent motion capture sessions. Exaggerated motion must be avoided and all markers should remain in full view. This step should not require more than fifteen seconds.
10. After fifteen seconds passes from the moment **Record** was clicked, the system will automatically stop collecting and tracking marker data.

At this point, a Tracked Binary (TRB or TRC) file has been generated in the current directory and is ready for editing. Next, the markers must be hand identified according to the marker list built for the subject's marker set.

11. Choose **Post Process** from the Mode Buttons.
12. Click **Quick ID** and identify the unnamed markers according to the conventions described in Appendix C, Marker Sets.
13. Click **Rectify**.
14. Manually cleanup and identify all tracks in this range of the motion file.
15. Click **Create Template**.
16. Select **Face Template**.
17. Select the appropriate Frames Range:
    - **Current**—the current displayed frame
    - **Selected**—frames highlighted in blue, low to high in dashboard
    - **Visible**—what is displayed across the screen, as a function of the time zoom
    - **All Frames**—all frames
18. Click **Create Template**.

Note: You must use the Objects sub-panel to select the marker sets.

Face Template Considerations

1. Face templates link all markers invisibly to other markers for the Template ID and Streaming ID functions. With all markers linked to other markers, the Template ID works much more quickly.
2. Explicit linkages in the Marker Set are used for the Streaming (Real Time) Rectify and Post-Processing Rectify along with the two Linkage Stretch parameters. Generally the face template with many linkages works better than one with fewer linkages for Rectify to work. Use only relatively rigid links and asymmetric markers if possible.
3. Keep the Linkage Stretch Parameters in the **Motion Capture > Tracking** sub-panel at 7 and 5 (or close) to prevent mis-IDs and allow high enough performance.

Examples

A Face Close-Up Tutorial

For an example of facial motion capture data, refer to the **C:\Program Files\Motion Analysis\EVaRT50\Samples\Dave Face Stabilization** directory and open up the project file **FaceOnly.prj**.

With this project, you can review how face marker data is tracked with body marker data. The **FaceOnly.prj** project file defines a 17 marker face capture template.

To play the motion capture data, load the VC file **DaveFaceCloseup1.vc**. This was a capture done with a close-up view of the face taken by the video camera.

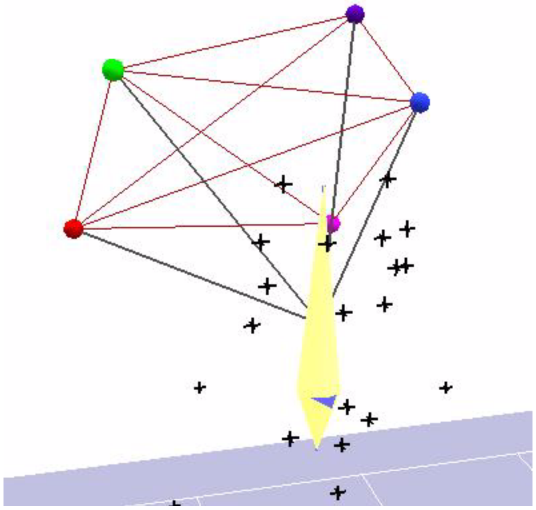
To see the video data:

1. Open another window and select a Data View type of "Full Color Video".
2. Right-click in the video window to bring up the AVI Frame Offset input dialog.
3. Set the value to –48.

This properly aligns the video data with the motion capture data.

This directory also contains a set of example files demonstrating how to use the marker stabilization tool in **EVaRT**. The file **Head.prj** defines a marker set of just the head markers for the performer (these markers are separate from the face markers). These head markers were tracked and exported to a TRC file—**Head.trc**. This TRC file was then used with Calcium and a single segment skeleton was created with the only segment being called "Head". This creates a 6DOF segment which exactly tracks the motion of the head of the performer.

Figure 15-5. "Head" Segment and its Driving Markers

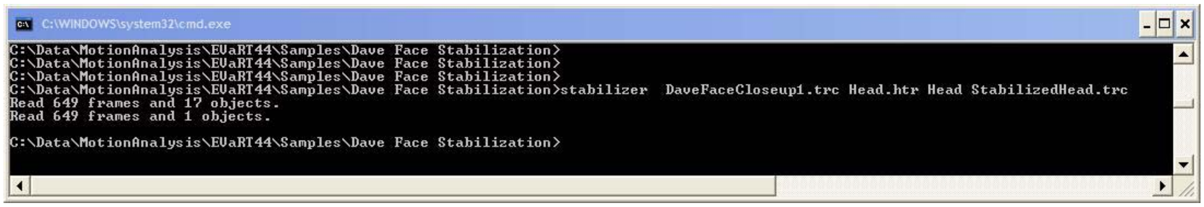


The project file is called **Head.prj** and it contains the Calcium setup information.

In **EVaRT**, the **Head.prj** file is loaded and the skeleton generating tools are turned on. In addition, the selection of the Streaming Option **Make object A relative to segment named "Head" of Main object** is turned on.

For each TRC file that you capture, you calculate then export the HTR skeleton to an HTR file. The TRC file and HTR file are used by a standalone command line program called "Stabilizer" (from the Mocap Toolkit) to generate a stabilized TRC file from the original TRC file. The stabilizer command would look as shown in Figure 15-6.

Figure 15-6. Stabilizer Command Dialog



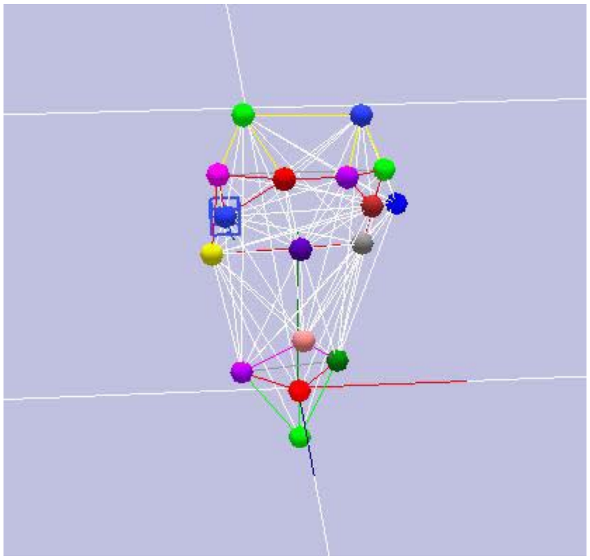
```
C:\Data\MotionAnalysis\EVaRT44\Samples\Dave Face Stabilization>
C:\Data\MotionAnalysis\EVaRT44\Samples\Dave Face Stabilization>
C:\Data\MotionAnalysis\EVaRT44\Samples\Dave Face Stabilization>
C:\Data\MotionAnalysis\EVaRT44\Samples\Dave Face Stabilization>stabilizer  DaveFaceCloseup1.trc Head.htr Head StabilizedHead.trc
Read 649 frames and 17 objects.
Read 649 frames and 1 objects.

C:\Data\MotionAnalysis\EVaRT44\Samples\Dave Face Stabilization>
```

This indicates that the **DaveFaceCloseup1.trc** file is to be stabilized by the **Head.htr** file using the segment named "Head" and the output is to be **StabilizedHead.trc**.

The face markers will be repositioned such that the motion of the head segment is removed. This effectively places the face markers at the origin of the data space, as shown in Figure 15-7.

Figure 15-7. Face Markers at Origin of the Data Space



You can view this TRC file by loading the **FaceOnly.prj** file into **EVaRT** and loading the tracks file **StabilizedHead.trc**.

This data is now ready for use in a facial animation system.

Facial Animation Techniques for Motion Capture

Types of Facial Animation

The goal of any facial animation technique is to move the geometry of the face around in a meaningful way. The way the mesh is modified must look very convincing to the eye since people are very attuned to facial motion and any anomaly will be quickly picked up. The two basic types of mesh modification used for facial animation are morphing and direct mesh deformation.

Mesh Deformation

Mesh deformation is a direct manipulation of the facial mesh. Markers are placed on the mesh and connected, such that, as the marker moves around so does the mesh. Each marker is given an area of influence on the mesh (areas of influence may overlap) that fades away the farther away the mesh is from the marker. Within any particular animation system, this technique is often identically the same as what is used to do full body skinning. This is not to be confused with clustering, where groups of markers are lumped together under one control handle (the cluster). For example, as the handle moves around so do the markers as a single group. Clustering is frequently used in facial animation but usually as a way of creating faces used for morphing.

Figure D-3. Face Model in Base Position with a Set of Markers

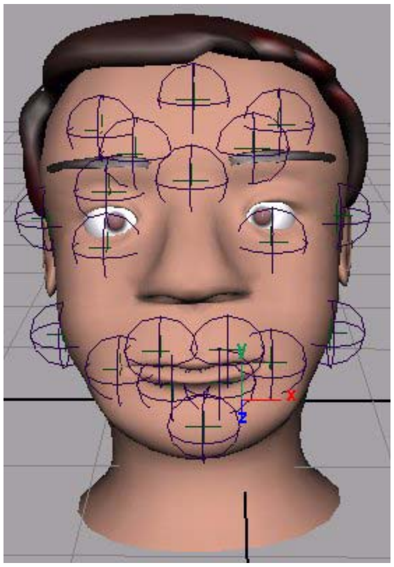
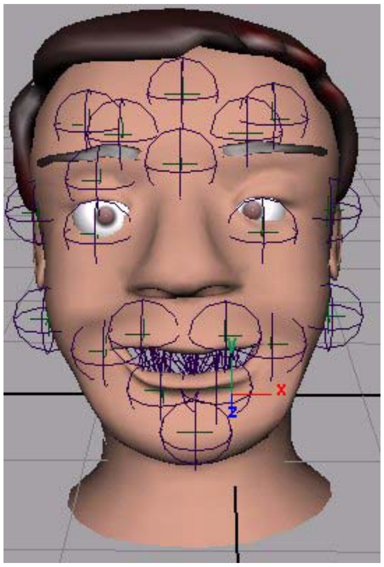


Figure D-4. Face with Motion Capture Data Applied to the Markers

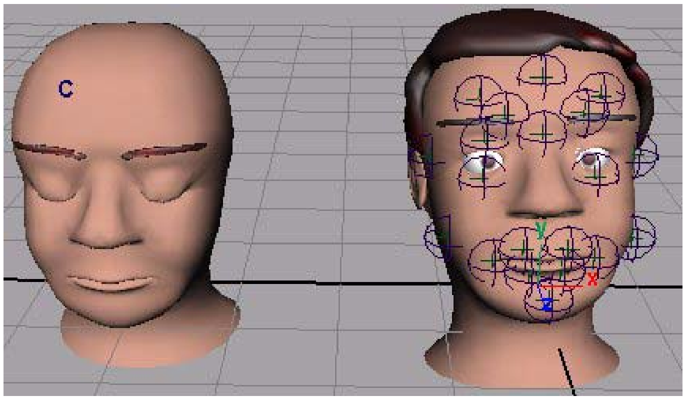


As the markers move around they pull the mesh with it. Care has to be taken on the areas of influence, especially around the mouth, so that markers affect only what they should affect. The upper lip markers, for example should not influence the lower lip.

Morphing

Mesh morphing is by far the most commonly used facial animation technique. It is an extremely powerful and easy to use technique. Like with the mesh deformation technique an animator starts with a base face. Copies of the base face are made, each copy is modified into a different facial expression (open mouth, smile, eye blink, etc.). To create a blend of these expressions, the animator specifies how much of each expression is used to compose the result. For example, 50% open mouth, 10% smile, 100% eye blink. Note that the percentages do not have to add up to 100. The animator only specifies how much of each expression goes into the face. Often times the expressions are called sub-expressions, morph targets, or simply targets.

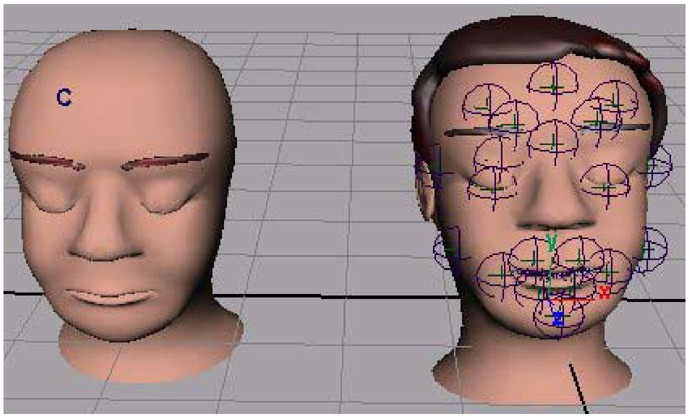
Figure D-5. Base Face with the Eye-blink Expression to the Left



This is the same face as used in the mesh deformation example. This demonstrates how it is possible in some animation systems to combine the techniques for even more powerful results.

A careful inspection of the base head image with the markers should reveal that there is only one eye-lid marker. It is on the right eye of the character. This particular facial motion capture data set had only one eye-lid marker so it would not be possible to use the mesh deformation technique to animate the eye-blinks of both eyes. Only the right eye could be used. However, using the morphing technique, the up-down motion of the right eye-lid marker can be used to control the contribution of the eye-blink morph target.

Figure D-6. Result of Combining Techniques



The right eye-lid marker has moved down a small amount to indicate that the actor blinked. Using the morph target on the left, both eyes appear closed when the target expression is applied to the final result on the right.

Unlike the mesh deformation technique, the morph target technique uses multiple meshes to do the facial animation. One requirement for all the morph target meshes is that they have exactly the same topology (the exact same number of vertices and polygons with exactly the same connections between them). Therefore, it is the usual practice to model the base face first, then make copies of it for modifying into other expressions.

Using Motion Capture Data with Facial Animation

This section describes how motion capture data is used with each of the facial animation techniques. The direct mesh deformation technique is extremely well suited to using motion capture data while morphing is very badly suited to using motion capture data. By themselves, each technique has its advantages and disadvantages. The correct answer for an animation system lies in the ability to use both simultaneously which allows the animator to have the best of both worlds. Each is described in the following subsections.

Facial Retargeting with Offsets for Mesh Deformation

The marker placement on the actor rarely coincides exactly with a corresponding marker placement on the character. A character's face is almost always exaggerated in some fashion that makes it impossible to find an actor to exactly match it. However, without careful placement of the markers on the mesh of the character, the deformation of the mesh simply will not work. The solution which satisfies both of these problems is to use the motion of the actor as an offset from the base position of the character.

To use this solution, you need to create a marker set on the mesh of the character that has the same number of markers with the same names as the marker set of motion capture data from the animator. The only difference between the two sets of markers is their starting positions in the base (neutral) pose of the faces. Rather than using the absolute position of the makers from the actor, you calculate the offset of motion of a marker from its base position. That is, how far it has moved from its starting point. This offset is what you apply to the character's markers. This way it doesn't matter if the character's face is really wide or really long or otherwise oddly proportioned. The starting points of the markers will always make sense and their motion from the actor will almost always work.

You can even scale the magnitude of the offset motion to exaggerate the motion or to dampen it.

The advantage to this technique is that it is technically easy to understand and implement. The drawback is the lack of high level expression control for the animators. If there are expressions that couldn't be captured (or weren't captured) it is hard to use keyframe animation on the mesh deformation markers to create totally new expressions.

Gesture Recognition for Morph Targets

The advantages and disadvantages for using morph targets are somewhat reversed with respect to the mesh deformation technique. Morph targets are much easier to use by animators to control expressions at a high level. Standard keyframe animation techniques work well with morph targets. On the other hand it is extremely difficult to create a general purpose ability to use motion capture data within such a system. Some simple and useful exceptions are found for parts of the face (such as the eye-lid example used above, or perhaps the jaw) but for some parts of the face, most notably around the mouth, it is very hard.

Most facial expressions do not limit themselves to a single spot on the face (such as the location of a single marker). Each facial expression moves many markers at once. A smile, for example, not only moves all of the markers around the mouth but it also moves markers around the eyes, temples and forehead (most people squint when they smile). So there isn't an easy way of linking a smile morph target to one or two motion capture markers. A smile is a true smile if and only if a whole set of markers move in just the right way. Systems capable of doing this kind of analysis have been made for doing realtime facial animation but this technique has not yet found its way into most animation systems.

Currently, the most advanced facial animation systems (the ones used to make some of the popular feature length animated features) use knowledge of skeletal and muscular anatomy to understand how the underlying tissue affects the skin movement of a character. These complex animation systems are all morph targets based in the sense that the animator still works with a blend of high level expressions to achieve their final result. They still say "I want half a smile" and "part of a smirk". The animation engine accounts for muscle and bone movement while composing the final result for the skin.

Other Facial Animation Inputs

Motion capture data isn't the only kind of input used for doing facial animation. A summary of other techniques is given here.

Keyframe Animation

All animation systems have keyframe animation at their core. The ability to use keyframe animation in conjunction with motion capture data is vital to getting the best overall results. It is important to use the keyframe tools without damaging the motion capture data. Some keyframe animation systems require that the motion capture data be simplified in order to control the data with keyframes. This is a mistake of large proportions as motion capture data should never be decimated. Motion capture data can't quite get everything that an animator will need from the motion so extra motion has to be layered on top. This is true of all motion capture types (face, body, hands) and devices.

Phoneme Recognition

Lip-synching is an important sub-problem of facial animation. The motion of the face (particularly the lips) must be synchronized to the audio track of the voice talent. The classic technique is for the animator to listen to the audio track and keyframe animate the facial expressions to match. The first part is to get the mouth in the right position to match the syllable. If the animator is using a morph target technique, it is very common to have a series of morph targets, each representing a common phoneme used in speech. This makes it straightforward, but time consuming to animate.

There are a number of automatic phoneme recognition technologies available for evaluating audio input and generating phonemes. This information can be used as a source of animation data for facial animation. Not only is phoneme recognition hard to get right, but the general approach has inherent limitations. Phoneme recognition can be helpful, but will never entirely solve the problem of facial animation. A summary of the drawbacks is as follows:

- **Too precise**—At any given moment the phoneme generator gives you only one phoneme (this will improve in the future). There is no notion of blending between them. All people slur their syllables to one degree or another, this kind of information is missed.
- **Anticipation**—Almost all sounds require a setup motion for the face. You open your mouth before you actually say anything, the audio track doesn't have that kind of information.
- **Other facial movement**—When people talk, their necks, ears, and other parts of the face move around significantly. This information is not conveyed. Lack of eye blinking information is perhaps the most important.
- **Non-audible facial expressions**—Most people intersperse their conversations with a variety of facial expressions to punctuate the conversation.

Despite these limitations an automatic phoneme generator can provide an excellent first pass at facial animation with the intent of going back over it to augment it with more facial animation information.

Eye Movement

Eye motion is a subtle, but a vital part of facial animation that must be present. A variety of techniques exist for obtaining eye motion, but it is difficult to get without hampering the acting talent. The most common approach is to take a video image of the eye and track the eye movement from the video footage. Some techniques track the whites of the eyes, others the pupils. Some use visible light, others use infrared.

In all cases, a 2D image is used to generate information about the translational movement of the eye in the image. This is then turned into rotation information to rotate the eyeball of the character.

Waldos

Waldos are physical input devices use as puppeteering controls for characters. Each input type is given a high level meaning such as head rotation, eye-blink, or a particular facial expression. For this reason, waldos and morph target facial animation systems work well together.

Other Motion Capture Issues

A miscellaneous collection of issues which affect, or are related to, facial motion capture are detailed in the following sub-sections.

Marker Size and Capture Volumes

Marker size, camera resolution, and capture volume calibration are all key elements to determining how large the capture volume can be and how much of the performer can be captured at once. Camera refresh rates and the number of markers can affect this too, although they're not as important. The latest camera systems have higher resolutions and the latest software has easy to use techniques for handling lens distortion and capture volume calibration. This adds up to the ability to have smaller markers and more of them which allows for full body and face motion capture simultaneously.

Having face and body data at the same time is an important technological hurdle. It simplifies a great number of face-body coordination issues and allows for real-time processing of the data so that live motion capture sets can be created (a live set is when the data is acquired, processed, applied to a virtual character and rendered at 30 frames a second).

Marker Stabilization

Sometimes the facial animation techniques require working with the data in a simple reference frame as though the head were an object by itself sitting on a table top. If the facial motion capture data is captured as part of a full body and face capture, then the facial markers have to be segregated and recalculated relative to the motion of the head segment of the body. This process is known as stabilization. This is a vital tool for keeping the facial data under control.

It is particularly important to have good, solid head motion in your character skeleton if you use this technique. Any amount of slippage in the motion of the head relative to the facial markers will result in jittery, noisy face data.

Sync to Body Capture

Ideally, the face and body are captured simultaneously so that the data is automatically synchronized because it's all part of the same data set. The good news is the latest motion capture systems allow for this. Global time information needs to be encoded in all motion files so that they can be later synchronized if they're not captured simultaneously. Time stamp information is always useful to have in any case.

Motion Capture of Hands

The motion capture of hand motion, and the fingers to be more specific, presents many of the same issues as facial animation. The capture volume limitations are about the same since the markers are about the same size. It is even common to use morphing techniques on the hands like on the face rather than treating the hand as a mini-skeleton and animating it like you would animate the full body. Certain hand gestures are very common so it's effective to model those few (fist, flat hand, pointing a finger) and morph between them. If motion capture data is used, however, skeleton animation techniques are easier to use and apply to the hands.

Limitations

Facial motion capture does have some limitations, not all the information that an animator might want can be captured directly from the face of the actor. Some examples are:

- **Tongue**—You can't put markers on the tongue. There is no effective way of capturing the full motion of the tongue with any kind of technique.
- **Neck**—Various regions of the neck move while talking. The motion of the tongue causes the underside of the jaw to move while swallowing and breathing causes other areas to move. Extra markers could be placed under the jaw and around the neck but then visibility issues become a concern.
- **Eyes**—Markers can't be used to track the eyes. Other techniques might be used for this.
- **Curl and other twisting motions**—The skin of the face doesn't just travel in straight lines. Many parts of the face scrunch and curl around. Pursing one's lips or pouting motions cause the lips to bend around in a variety of ways. Markers do not directly transmit this information, only careful placement of groups of markers can effectively sense this.
- **Number of markers**—Ideally it would be best to use as many markers as you can put on the face. Capture limitations prevent this so much information that might theoretically be measured will have to wait for higher resolution cameras and even smaller markers.

Despite this list, facial motion capture is, by far, the best overall technique for generating facial animation from a performer. No other kind of system is as versatile or productive.

Production Issues

Many practical issues creep into the animation process that do not have much to do with techniques for animation but rather with the process of animation itself. That is to say, it has to do with the relationship between the animator and the production tools. This is true for all tools, especially facial animation tools. Here is a list of issues that anyone doing facial animation should keep in mind:

- **Requirements do change**—Real productions do not march relentlessly from front to back, animators have to go back over the data many times to get the result they need. For example, a common mistake in morph target facial animation is the realization that you need more flexibility in a certain part of the mesh so you can make a new target expression that you suddenly discovered you needed. Since all the expression meshes must exactly match, you have to update all the existing meshes to incorporate your new change. This can be tedious and error prone. Some morph target systems do automatic updates for you. Be ready for this when setting up your workflow. Consider the possibility that you might, at times, have to work backwards through problems.
- **Facial animation is just one element**—Facial animation would be somewhat easier if all you had to worry about is the face. The problem is that you almost always have to attach the face to a head (and therefore to a body). The relationship between the face and body elements must be considered when setting up a character for animation.
- **Interactive versions versus full render versions**—The high resolution final images (if that is the final output) require high resolution facial meshes. This sometimes hampers the inter activeness of the animation system. The ability to use low resolution meshes for interactive work and then replace them before the final product is a valuable production tool.
- **Synchronization**—All input data needs to be synchronized. Global time information needs to be present in all the data so that as the animator works with different kinds of data (face, body, voice, video), they can be matched up in time.
- **Output**—The final output of motion data is not always a final image. The final output might be animation data sent to a game engine (or some other kind of interactive environment). In which case, the algorithms which underlay the facial animation need to be present in the game engine so it can reproduce the facial animation interactively.

Appendix E Forcepla.cal File Format

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Using Kistler Forceplates	E-8
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General Information

Up to eight forceplates may be placed within the video capture space to measure gait forces. While **EVaRT** gathers video data, it simultaneously acquires forceplate data.

To accomplish this, the forceplate output is connected to an analog input card in the **EVaRT** system. The forceplate data is interpreted using a file called **forcepla.cal**. When **EVaRT** reads in the trial data, it first searches the current directory where the project resides for the **forcepla.cal** file. If none is found, it then searches in the directory: **C:\Program Files\Motion Analysis\EVaRT5\Samples\Example Forcepla.cal Files.**

The **forcepla.cal** file contains information describing the location, orientation, and calibration of each forceplate used. The exact form of the file will depend on the forceplate manufacturer. Figure E-1 shows the file form for Bertec and AMTI forceplates. Figure E-2 shows the file form for Kistler forceplates.

The **forcepla.cal** file contains no text, only numbers. For multiple forceplates, the data for each forceplate in the system is included in one **forcepla.cal** file (see Figure E-4).

Note: The **forcepla.cal** file must be in the same directory as either the **EVaRT50.exe** file or the ***.prj** file. Otherwise, the forceplate outlines will not appear in the 3D collection view.

Note: **Forcepla.cal** files in the past have been named with a “t”, as forceplate. Be sure to check that there is no “t” in **forcepla.cal**.

Example **Forcepla.cal** files for each type of forceplate (AMTI, Bertec, and Kistler) can be found in the directory: **C:\Program Files\Motion Analysis\EVaRT5\Samples\Example Forcepla.cal Files.**

Figure E-1. Forcepla.cal File Structure for Bertec and AMTI Forceplates

Line# Description

1 Forceplate number (1 through 8)
2 Forceplate scaling factor and [optional length and width of forceplate]
(25 for AMTI setup with amplifier gain switches set to 4000)

3
4
5 6x6 forceplate calibration matrix (Inverted Sensitivity) provided by the manufacturer
6
7
8

9 Xo Yo Zo True XYZ origin relative to the geometric center of the forceplate—in cm (provided by the manufacturer).

10 Xc Yc Zc XYZ location of the geometric center of the plate
with respect to your video coordinate system.
(the video calibration system's origin)—measured in cm

11
12 3x3 forceplate orientation matrix to make the forceplate coordinate system match the laboratory coordinate system
13

Figure E-2. Forcepla.cal File Structure For Kistler Forceplates.

Line# Description

1 Forceplate number followed by "K" to indicate a Kistler forceplate.
2 Forceplate scaling factor and [optional length and width of forceplate]

3
4
5
6 8x8 forceplate calibration matrix created by the user
7
8
9
10

11 Xo Yo Zo position of the forceplate transducers in cm
(provided by the manufacturer)

12 Xc Yc Zc XYZ location of the geometric center of the plate
with respect to your video coordinate system.
(the video calibration system's origin)—measured in cm

13
14 3x3 forceplate orientation matrix to make the forceplate coordinate system match the laboratory coordinate system
15

Forceplate File Data

Forceplate Number

A unique number is assigned to each forceplate in the system.

Forceplate Scaling Factor and Optional Length & Width

The scaling factor depends on the forceplate manufacturer and the gain setting. Length and width are optional and are measured in cm. Length and width orientation is also dependent on the forceplate manufacturer. Refer to later sections specific to the manufacturer of your forceplate.

Forceplate Calibration Matrix

The calibration matrix transforms the output of the forceplate into forces and moments. Refer to the section later in this appendix specific to the manufacturer of your forceplate.

True XYZ Origin

This is the offset of the origin of the forceplate XYZ coordinate system relative to the center of the top surface of the forceplate. Each manufacturer provides this offset value.

XYZ Location in Video Coordinate System

This tells the **EVaRT** system where the center of the top surface of the forceplate is located relative to the **EVaRT** video coordinate system. Once this is established, the video calibration frame must be placed in the same location each time you calibrate. The center of the top surface can be found by measurement or drawing diagonal lines from opposite corners. The units of measurement are centimeters (cm).

3x3 Orientation Matrix

This matrix describes the orientation of the forceplate relative to the laboratory or room coordinate system. It is a matrix of direction cosines of the angles between the forceplate coordinate system and the laboratory coordinate system. Using the terminology cos(Xplate, Xlab) to indicate the angle between the forceplate X axis and the laboratory X axis, the matrix takes the following form:

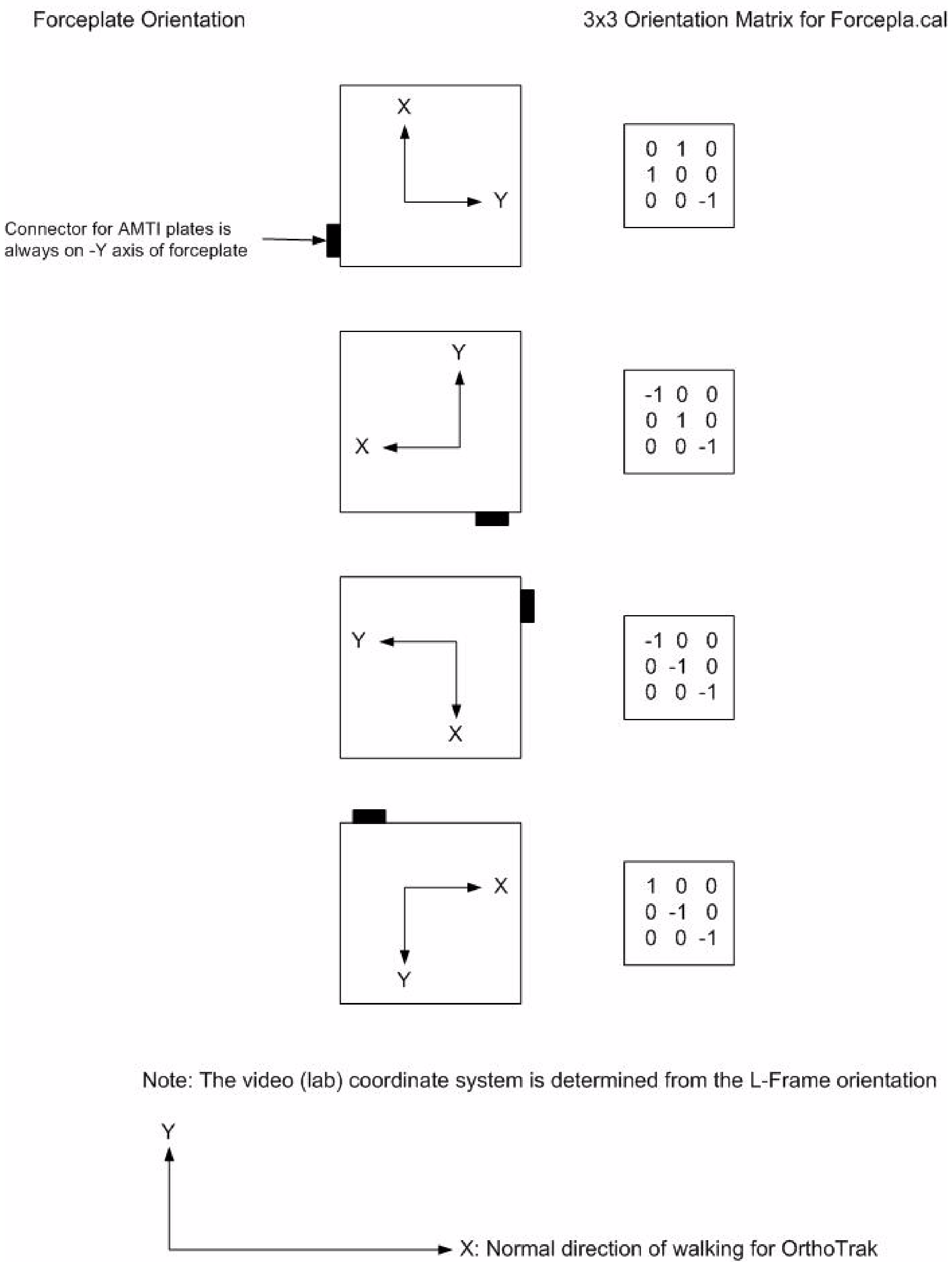
$$\begin{array}{cc} & \begin{matrix} \mathbf{X}\text{plate} & \mathbf{Y}\text{plate} & \mathbf{Z}\text{plate} \end{matrix} \\ \begin{matrix} \mathbf{X}\text{lab} \\ \mathbf{Y}\text{lab} \\ \mathbf{Z}\text{lab} \end{matrix} & \begin{bmatrix} \cos(\mathbf{X}\text{plate}, \mathbf{X}\text{lab}) & \cos(\mathbf{Y}\text{plate}, \mathbf{X}\text{lab}) & \cos(\mathbf{Z}\text{plate}, \mathbf{X}\text{lab}) \\ \cos(\mathbf{X}\text{plate}, \mathbf{Y}\text{lab}) & \cos(\mathbf{Y}\text{plate}, \mathbf{Y}\text{lab}) & \cos(\mathbf{Z}\text{plate}, \mathbf{Y}\text{lab}) \\ \cos(\mathbf{X}\text{plate}, \mathbf{Z}\text{lab}) & \cos(\mathbf{Y}\text{plate}, \mathbf{Z}\text{lab}) & \cos(\mathbf{Z}\text{plate}, \mathbf{Z}\text{lab}) \end{bmatrix} \end{array}$$

Since, in real situations, the forceplate should be aligned with the room coordinate system, the numbers in this matrix will always have one of three values:

Angle = 0 cos = 1
Angle = 90 cos = 0
Angle = 180 cos = –1

Example matrices are shown in the following figure:

Figure E-3. Forceplate Coordinates System


Forceplate Orientation
3x3 Orientation Matrix for Forcepla.cal
X
Y
Connector for AMTI plates is always on -Y axis of forceplate
0 1 0
1 0 0
0 0 -1
Y
X
-1 0 0
0 1 0
0 0 -1
Y
X
-1 0 0
0 -1 0
0 0 -1
X
Y
1 0 0
0 -1 0
0 0 -1
Note: The video (lab) coordinate system is determined from the L-Frame orientation
Y
X: Normal direction of walking for OrthoTrak

Forceplate Scaling Factor, X-Width and Y-Length

The scaling factor depends on the forceplate manufacturer, and the forceplate amplifier gain setting and the voltage range.

Table E-1. Sample Forceplate Scaling Factors

Forceplate Manufacturer	Scaling Factor
AMTI	For Gain 4000—Use 25.0
Bertec	Use 1.0
Kistler	±10 Volt Amplifier—Use 1.0 ±5 Volt Amplifier—Use 0.5

The x-width and y-length are the forceplate measurements in centimeters as measured in the forceplate coordinate system. Check the manufacturer’s specifications. If no x-width and y-length values are used, AMTI and Bertec forceplates default to 18-inches by 20-inches, and Kistler forceplates default to 50-centimeters by 50-centimeters.

Using AMTI and Bertec Forceplates

AMTI Gain Setting

For the AMTI forceplates, a gain of 4000 mV and a cutoff frequency of 1050 kHz is recommended. Using the method outlined in the AMTI literature, this gain yields a scaling factor for the **forcepla.cal** file of 25. The example in Figure E-4 uses an AMTI forceplate.

Bertec Gain Setting

A gain setting of 10 for Bertec forceplates is recommended. In the **forcepla.cal** file you should set *scaling factor = 1 / gain*, yielding a **scaling factor** of 0.1.

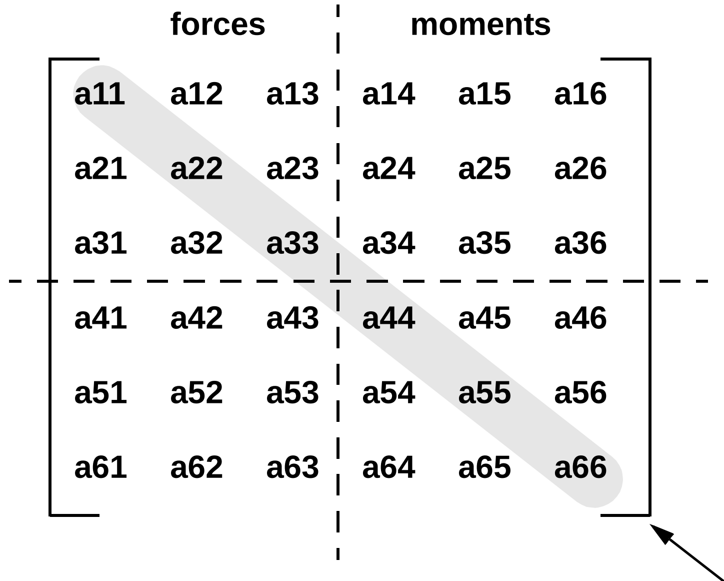
The Calibration Matrix

The 6x6 calibration matrix (Inverted Sensitivity) is provided by the manufacturer (AMTI or Bertec). It is used to transform the output of the forceplate into three force vectors and three moment vectors. The form of the matrix is shown in Figure E-5. The main diagonal of the matrix (upper left to lower right) represents the basic channel sensitivities. The off diagonal terms represent the channel cross-talk.

Figure E-4. Example Forcepla.cal File for 2 AMTI Forceplates

```
1.
25  51  46.5
2.9350    0.0040    0.0130    –0.0480   –0.0400   0.0050
–0.0020   2.9930    0.0470    0.0080    –0.0250   0.0410
–0.0270   0.0120    11.5420   –0.0240   0.0030    0.0160
0.0000    –0.0070   0.0000    1.5390    –0.0110   0.0010
–0.0070   –0.0020   0.0000    0.0000    1.5350    –0.0040
0.0020    0.0020    –0.0050   0.0020    –0.0040   0.7440
–0.1000   –0.0260   –3.8000
5.6000    –25.7000  –4.2000
0.0000    1.0000    0.0000
1.0000    0.0000    0.0000
0.0000    0.0000    –1.0000
2.
25  51  46.5
2.9340    0.0090    0.0020    –0.0130   0.0170    0.0110
0.0120    2.9750    0.0450    0.0310    –0.0200   0.0340
0.0050    0.0020    11.5480   –0.0210   –0.0090   0.0070
–0.0040   0.0010    0.0000    1.5470    –0.0020   –0.0030
0.0010    –0.0020   0.0000    0.0020    1.5450    –0.0080
0.0020    0.0060    0.0000    0.0010    –0.0060   0.7480
–0.1000   0.0300    –4.2000
56.5      –25.7000  –4.2000
0.0000    –1.0000   0.0000
–1.0000   0.0000    0.0000
0.0000    0.0000    –1.0000
```

Figure E-5. The 6x6 Calibration Matrix


forces
moments
a11 a12 a13 a14 a15 a16
a21 a22 a23 a24 a25 a26
a31 a32 a33 a34 a35 a36
a41 a42 a43 a44 a45 a46
a51 a52 a53 a54 a55 a56
a61 a62 a63 a64 a65 a66

The main diagonal represents the basic sensitivities for each channel:

Force units $\frac{V \cdot N}{\mu V}$

$\frac{V \cdot N \cdot m}{\mu V}$

The information provided by the manufacturer may include only the basic sensitivities for each channel with no values for cross-talk. In this case, the matrix should be filled with the basic sensitivities on the main diagonal and zeroes elsewhere.

Also notice that the upper right quadrant of the matrix contains the force sensitivities and the lower right contains the moment sensitivities. In every case, the force sensitivities are greater than the moment sensitivities. **EVaRT** uses this information to switch matrix quadrants (permute the matrix) if the manufacturer should supply the matrix with the moments on the left and force on the right.

Note: The calibration matrix is intended to be used with your plate’s coordinate system, not the room’s. For this reason, if your plate is not aligned with the room, correct it with the 3x3 orientation matrix, not by switching wires or A/D signal names.

Using Kistler Forceplates

Signal Names

The Kistler forceplate has 8 outputs. Therefore, two forceplates will use 16 channels on the A/D card. The signal naming conventions are shown in Figure E-6. The names in the analog ANB (or ANA) file must appear exactly as shown in the **EVaRT** ANB (or ANA) column.

Gain Setting

With the Kistler forceplate, the Charge Amplifier (model 9865) should be set on **range #3** for the X/Y and Z range settings (X and Y are set together). This is the 10,000 pC setting.

This setting can be changed if desired, but the **forcepla.cal** file will have to reflect the change. A **gain = 1** on the A/D board should be used since the Kistler outputs 10 V full scale.

Calibration Matrix

The Kistler forceplate requires an 8x8 calibration matrix. The matrix only contains non-zero data on the main diagonal (upper left to bottom right). All non-diagonal cross-talk elements are zero.

To calculate the values to use on the main diagonal of the matrix (assuming nominal sensitivity values of 7.8 and 3.8 pC/N):

X and Y Scaling	(10000 pC / 7.8 pC/N) / 10 V = 128.2 N/V
Z Scaling	(10000 pC / 3.8 pC/N) / 10 V = 263.4 N/V

Figure E-6 shows an example 8x8 matrix in a **forcepla.cal** file.

True XYZ Origin

This is a measure of the X, Y, and Z distances to the piezoelectric transducers used to generate the signals in the Kistler forceplates. These numbers are supplied by the manufacturer.

Figure E-6. Example Forcepla.cal File For a Kistler Forceplate

```
1K
1.0
128.2   0       0       0       0       0       0       0
0       128.2   0       0       0       0       0       0
0       0       128.2   0       0       0       0       0
0       0       0       128.2   0       0       0       0
0       0       0       0       263.4   0       0       0
0       0       0       0       0       263.4   0       0
0       0       0       0       0       0       263.4   0
0       0       0       0       0       0       0       263.4
12.000  20.000  –5.4000
0.0     0.0     0.0
1       0       0
0       –1      0
0       0       –1
```

General Notes On Kistler Forceplates

1. Since the Kistler forceplate format is flagged with a "K" after the forceplate number, Kistler and other forceplates may be included in a single system.
2. The proper way to orient the forceplate is the 3x3 orientation matrix, not the calibration matrix.

Note: Do not switch the cables to the A/D board.

3. Keep the Long Term Constant turned off on the charge amplifier.
4. Reset the charge amplifier before each test, or at least every few tests. This re-establishes the zero for the charge amplifier.

Using Kyowa Dengyo Forceplates

The Kyowa Dengyo force plate has now been incorporated into **EVaRT**.

The following is a description of the procedure for calibration using the RealTime interface as well as a description of the **forcepla.cal** for Kyowa Dengyo force plates.

The automatic calibration of the Kyowa Dengyo force plates is now implemented in **EVaRT**. At the end of the calibration procedure the Real Time system creates a new **forcepla.cal** file containing the latest calibration values (zero, +cal and –cal) for computing the distortion conversion coefficient. The calibration procedure is as follows:

1. Make sure that the Kyowa Dengyo force plates are connected to the National Instruments A/D data acquisition hardware with the following channel assignments:

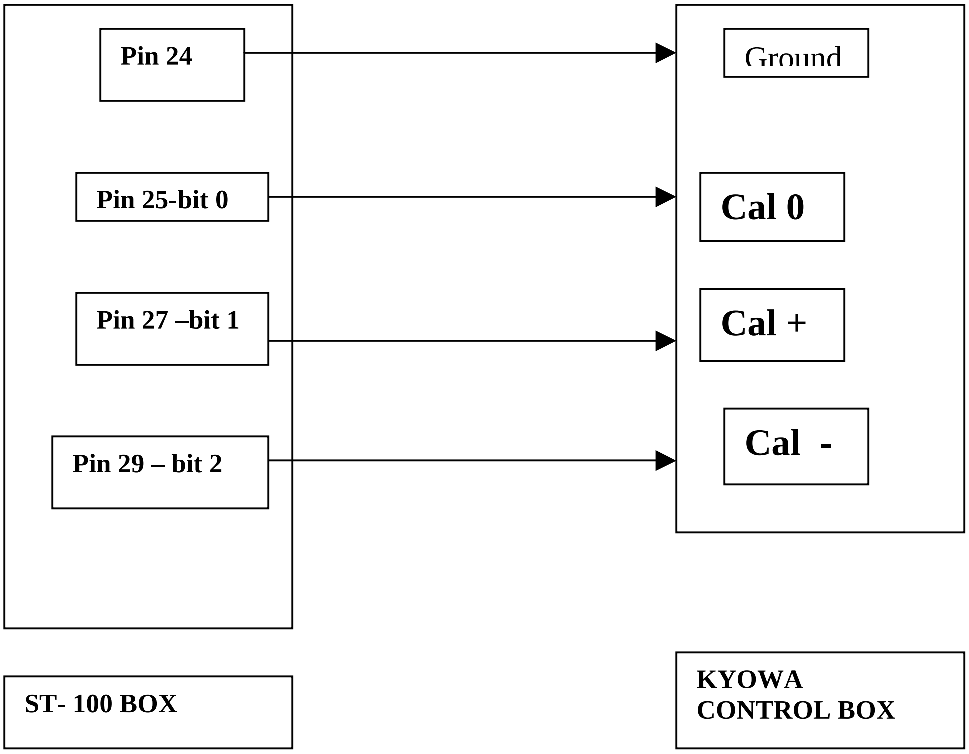
Table E-2. Force plate channels for Kyowa Force Plate number 1

Analog Channels	Kyowa Dengyo Force Plate Channels
Channel 1	FZ11
Channel 2	FZ12
Channel 3	FZ13
Channel 4	FZ14
Channel 5	FX114
Channel 6	FX123
Channel 7	FY112
Channel 8	FY134

Follow a similar connection and naming (FZ21, FZ22 etc.) sequence for additional plates.

2. Connect the ST-100 box terminal pins 25, 27, and 29 (pin 24 is ground) which correspond to bits 0, 1 and 2 of the digital I/0 of the National Instrument A/D board to Cal (o), Cal (+) and Cal (-) of the Kyowa Dengyo interface box.

Figure E-7. Kyowa Connection Block Diagram



3. The Folder containing the **EVaRT** executables must also have a **forcepla.cal** file (previously created) according to the format for **forcepla.cal** file for Kyowa Force Plates.

   Load a project file that has the Kyowa forceplates enabled in the Analog set up panel

There is a new button named **Calibrate Kyowa Force Plates** in the **Setup > Misc** sub-panel.

After making sure all the connections are properly made click on the **Calibrate Kyowa Force Plates** button.

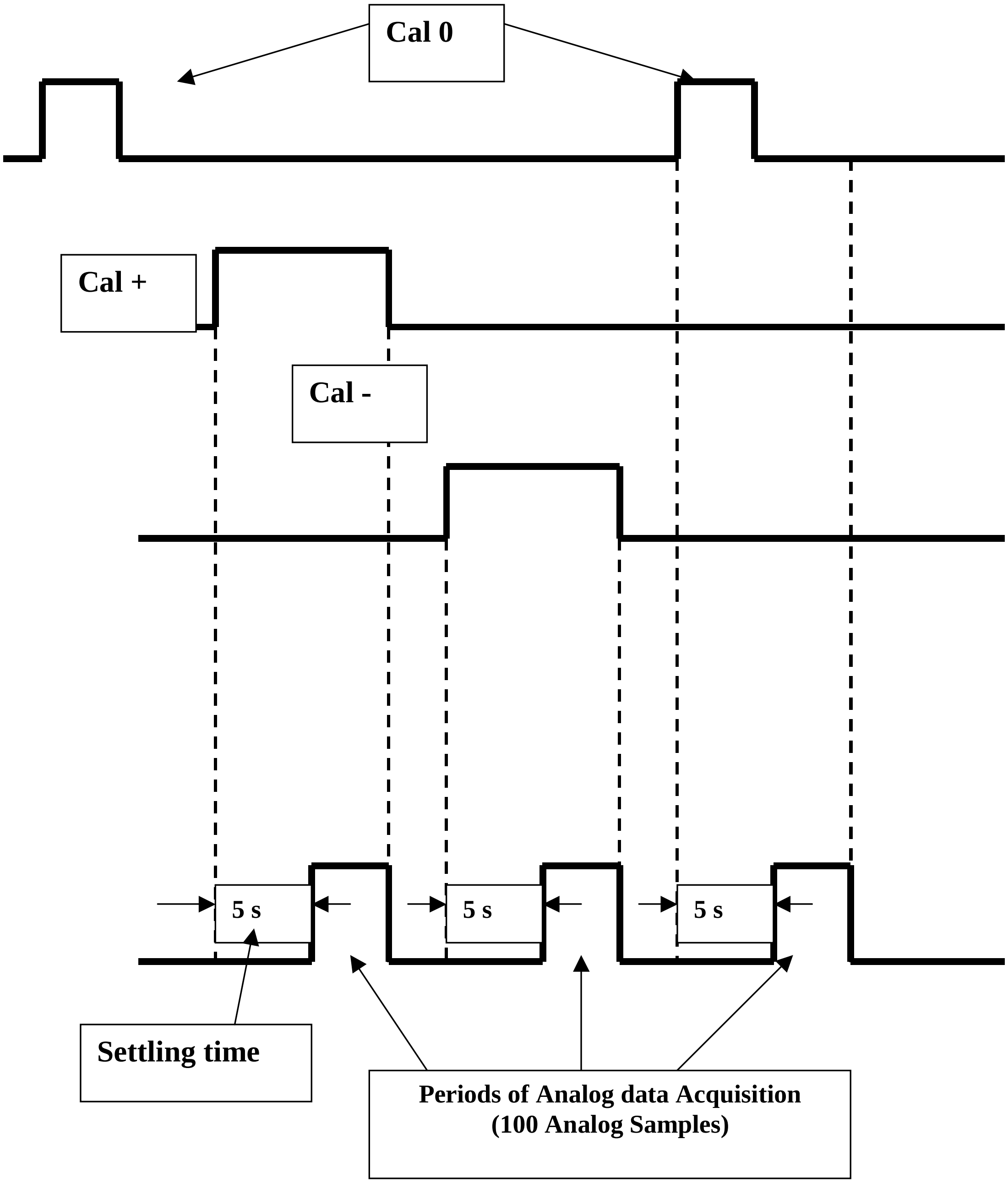
The following sequence of events are initiated.

- TTL pulses are sent, in sequence to CAL 0, CAL+, CAL- and CAL ZERO terminals of the Kyowa control box as shown on the timing diagram.
- 100 samples of analog data are collected across all the Kyowa force plate channels, 5 seconds after the initiation of the TTL pulses.

- Approximately 1 minute is required for the calibration.
- The average of the 100 samples (in A/D units) are computed and data are written into a **forcepla.cal file** in the same folder as the loaded project file.

  The timing sequence of the TTL pulses and the analog data acquisition is shown on the next page.

Figure E-8. Timing Diagram for Kyowa Force Plate Calibration


Cal 0
Cal +
Cal -
5 s
5 s
5 s
Settling time
Periods of Analog data Acquisition
(100 Analog Samples)

Description of Forcepla.cal File for Kyowa Dengyo Forceplates

[Line 1] [Force plate number Kyowa] Example:1Kyowa, 2Kyowa etc,.

[Line 2] [Scale factor Width Length]

[Line 3] [Calibration Range Settings in the order FZ1 FZ2 FZ3 FZ4 FX14 FX23 FY12 FY34]

[Line 4] [Zero values in A/D units written by EVaRT Calibration step

[Line 5] [Cal + values in A/D units written by EVaRT Calibration step]

[Line 6] [Cal - values in A/D units written by EvaRT Calibration step]

[Line 7] [Load Conv.Coeff.*Voltage Conv. Coeff.*9.801] same order as above

[Line 8] [XY axis Conversion Coefficients(XY locations of Z-axis force Transducers) in centimeters]

[Line 9] [X location of Fy and Y location of Fx transducers in centimeters]

[Line 10] [Location of Geometric Center of Force Plate with respect to video coordinate origin in video coordinates]X Y Z in Centimeters

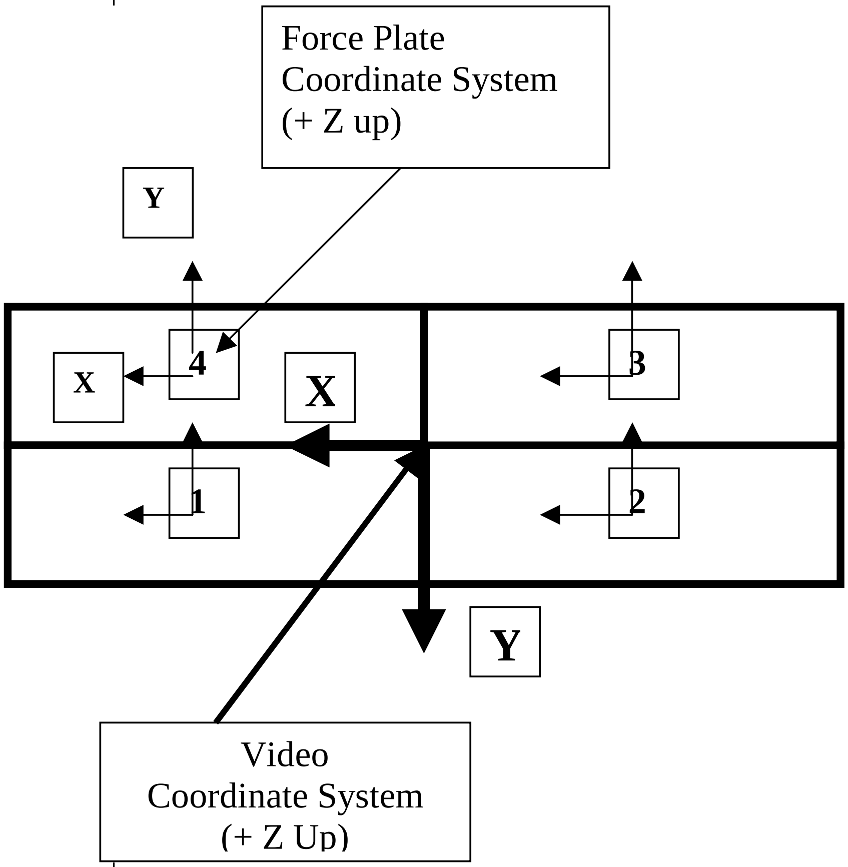
[Line 11]

[Line 12] [Force Plate Orientation Matrix]

[Line 13]

Example Kyowa Dengyo Forcepla.cal File

Figure E-9. Example Forcepla.cal file for 4 Kyowa Dengyo Force Plates


Force Plate
Coordinate System
(+ Z up)
Y
X
4
X
3
1
2
Y
Video
Coordinate System
(+ Z Up)

```
1Kyowa
1.0  60  180
2000     2000     2000     2000      500      500
500      500
-3    2     -4    3     6     -6    5     -6
1600  1601  1602  1599  803   802   800   802
-1608 -1609 -1608 -1608 -805  -804  -804  -805
0.00103  0.00104  0.00103  0.00103  0.00073  0.00073 -
0.00071 -0.00071
-22.5017 –22.3307  22.8603  22.1836  55.7321 –55.2022
–54.9477  54.5368
23.35  51.00
90.0  30.0  0.00
 0.0000   1.0000   0.0000
-1.0000       0.0000   0.0000
 0.0000   0.0000   1.0000
2Kyowa
1.0   60    180
2000     2000     2000     2000      500      500
500      500
-8    5     -6    3     -22   26    -8    -11
1609  1606  1606  1607  803   803   805   803
-1608 -1607 -1605 -1607 -802  -804  -803  -802
0.00101     0.00102     0.00101     0.00101
0.00079     0.00072     -0.00074    -0.00075
-22.5648    -22.3288    22.3755     22.7563
54.8645     -55.3299    -55.3140    55.7631
23.35 51.00
-90.0       30.0        0.0
0.0000      1.0000      0.0000
-1.0000     0.0000      0.0000
0.0000      0.0000      1.0000
3Kyowa
1.0   60    180
2000     2000     2000     2000      500      500
500      500
-21   25    24    22    -18   21    -10   15
1613  1606  1605  1607  805   806   800   804
-1610 -1605 -1601 -1606 -803  -806  -808  -804
0.00102     0.00103     0.00101     0.00104
0.00072     0.00072     -0.00075    -0.00075
-22.5481    -22.3083    22.3729     22.7725
55.2674     -54.6867
-55.6732    55.1962
23.35 51.00
```

```
-90.0       -30.0       0.00
0.0000      1.0000      0.0000
-1.0000     0.0000      0.0000
0.0000      0.0000      1.0000
4Kyowa
1.0   60    180
2000     2000     2000     2000      500      500
500      500
-0    2     2     4     10    -3    6     -5
1602  1607  1604  1603  801   805   803   803
-1608 -1614 -1612 -1610 -805  -808  -807  -806
0.00104     0.00104     0.00102     0.00103
0.00072     0.00073     -0.00071    -0.00072
-22.3702    -22.5673    22.6288     22.4559
55.3667     -55.2103    -54.9972    55.2328
23.35 51.00
90.0        -30.0       0.00
0.0000      1.0000      0.0000
-1.0000     0.0000      0.0000
0.0000      0.0000      1.0000
```

Appendix F

SDK—Software Developers Kit

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SDK Overview

The SDK is available for the advanced user who wishes to incorporate the output data stream from **EVaRT** into a software application.

The Software Developers Kit, which provides the tools for interfacing your program with **EVaRT** is available by special request from Motion Analysis Corp. at Support@MotionAnalysis.com.

SDK Programming Example: Write your own Streaming Plugin

There is a Software Development Kit (SDK) which is written in the Visual C/Visual C++ language and an example C program that is available at no charge that demonstrates how to use the SDK. This allows our customers to use this as a starting point and creating their own program.

The sample program shows you how to connect to the **EVaRT** software and request that the kind of data that you want be transferred (Marker XYZ data and/or Skeleton HTR data). The sample C program then writes out the data to a disk file. Please also note that the data can be streamed either from the live camera data (that is happening in real time), or from the Post Processing software when you press the Play button. The data is the same either way and the SDK program does not even need to know since it comes across the same way. So, the customer can write the program from previously edited XYZ data in the Post Processing part of **EVaRT** and get that to working. Press the **Play** button, you see the edited tracks and the data is streamed to the SDK. Then they can connect to the cameras and get the same XYZ or HTR type data from the live cameras.

Appendix G

Import and Export File Formats

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Overview

The files generated by **EVaRT** fall into two main categories: ASCII and binary. ASCII files contain data in a text form that can be read by any text editor. They usually have descriptive headers that indicate the nature of the data that follows. Often these files are in a row and column format that allows data to be read and manipulated by spreadsheet programs such as **Excel**^{TM}. ASCII files are not compact and can be quite large.

Binary files contain raw binary data and are more compact than ASCII files. They cannot be read by a text editor. In general, binary files are not meant to be read by the end user.

mac_lic.dat

All Motion Analysis software requires a valid license to run. The license is keyed to a particular computer.

- For a **Windows NT** computer, it is keyed to the number of the dongle supplied by Motion Analysis.
- For **SGI** computers, it is keyed to the sysinfo-s number.
- For **Sun/Sparc** computers, it is keyed to the host id number.

The license file is ASCII and has the unique name **mac_lic.dat**. It is located in the **Motion Analysis** directory. Only one license file is used for all Motion Analysis software. Each additional software application beyond **EVaRT** is given a separate line in the license file, with the license type enclosed in square brackets **[ ]** followed by two license codes.

If you acquire new Motion Analysis software, you must use a text editor to enter the new line in your license file to enable your new software. This line can be typed in or entered by cutting it from the file you receive and pasting it into the existing license file. The order of the licenses in the file is not important and only those lines that start with a **[** (left bracket) are read by the software.

Note: If you are operating in Windows 2000, make sure that file extensions are not hidden, which is the default. This makes the **mac_lic.dat** look like **mac_lic,** which might be renamed to **mac_lic.dat.dat**. If this happens, the system will not recognize the license file.

Figure G-1. An Example of a Motion Analysis License File

```
Motion Analysis License File
Customer: MAC Customer
Platform: NT
SystemID: 19c
Created: 9/15/2005 1:42:26 PM
Sales Order#: 05-xxx
Entered By: Support
[EVa RealTime v4.4]  aed50167    873b2d56
[Analog Input]       b9806c31    d1567841
[OrthoTrak]          b2df5e69    8964274a
[Animation Plugins]  b1a46160    805b5c49
[Director/Sequencer] e1a04e65    85745819
[RT2 Animation Plugins] e3f05340    a069081b
[Analog Input]       b9806c31    d1567841
[Calcium 4]          e7ed5923    c363151f
[Skeleton Builder 4] a3f44279    99780c5b
[Reference Video 3.0] eb92592f    cf636a13
[Talon Streaming 4]  ecb36136    d65b4b14
[Talon Viewer 4]     86fb0714    f43d037e
[BioFeedTrak]        ac943872    92026c54
[Motion Composer]    c7f00e25    c534083f
This license has no expiration.
```

PRJ—EVaRT Project File

Every motion capture session must have a project file containing all system settings, equipment parameters, and other information related to the project. This file contains both equipment parameters common to many different setups and calibration values unique to one particular session. Among the data found in a project file are:

- the system setup
- the marker set
- calibration setup and results
- linkages between markers
- SkB segment definitions, coordinate systems, and hierarchies
- (optional) MoCap Solver segment definitions, joint types, and hierarchies
- camera type and parameters

In most cases, you will begin a session by loading an existing project file, editing it as necessary, and saving it in the directory where the motion data is to be saved. Any time you calibrate the system or edit project parameters, you should save the project file to disk to retain the new information.

Important

Project files contain ASCII data and it may be useful to view them using any text editor, however, you should never edit them in a text editor.

TRC—Track Row Column

The **.trc** file contains X-Y-Z position data for the reflective markers. This is an ASCII file in a Row/Column, horizontal tab delimited format that can be easily read into a spreadsheet program such as **Excel**TM and **Lotus**TM. The position data for each marker is organized into 3 columns per marker (X, Y and Z position) with each row being a new frame. The position data is relative to the global coordinate system of the capture volume and the position values are in the units used for calibration.

The file is made up of three parts:

- the file header,
- the position data header, and
- the position data.

All fields in this file type are separated by horizontal tabs.

File Header

The **.trc** file header occurs on the first three rows.

- Row one contains the path file type label (string), path file type number (int), path file type descriptor (string) and original directory path and file name (string).

- Row two contains the data rate label (string), the camera rate label (string), the number of frames label (string) and the units label (string).
- Row three contains the data rate value (real), the camera rate value (real), the number of frames (int) and data units (string).

Data Header

The data header occupies rows four and five.

- Row four contains the frame number label (string), the time label (string) and followed by the marker name labels (string). There are three horizontal tab characters between each marker name label. These names usually correspond to the location where a reflective marker was placed on the subject.
- Row five contains the column labels (string) for the position data starting on row six. For each marker name there is an X, Y and Z column. These axes labels have the trajectory numbers appended to them.

Position Data

Position data begins at row six. Column one of the data fields contain the frame number (int). Column two contains the time (real) and columns from three on contain the X, Y and Z position data (real) for each trajectory. There are three columns for every trajectory.

Empty Fields

An empty frame of position data (missing data) is represented as three consecutive horizontal tab characters.

Example

Shown below is a portion of a file with the following attributes:

- captured rate = 60 frames per second
- total frames = 90
- total reflective markers = 33
- units of measure = mm

Data for only the first 3 markers is shown, the remaining markers would appear in columns to the right. Also, data for only the first 12 frames is shown, the remainder would appear in rows below frame 12.

Figure G-2. An Example of a TRC File

```
PathFileType4 (X/Y/Z)          /usr/people/evademo/Oct14/MichelleInit1.trc

DataRate   CameraRate          NumFrames          NumMarkers                UnitsOrigDataRate

.60.0            60.0                 90                  33                       mm      60.0

Frame#Time   Head_Top                           LHead                       RHead                      . .

                   X1        Y1        Z1        X2        Y2        Z2        X3        Y3        Z3      . .

1     0.000  234.5437 1673.7619  232.2308  316.7533 1608.3785  218.5500  144.7963 1597.3691  274.4994      . .

2     0.017  235.2399 1673.4542  232.1284  316.6074 1608.2884  219.0597  144.7684 1597.8106  274.2137      . .

3     0.033  235.2361 1673.4926  232.1852  316.1265 1608.1984  219.7480  144.7296 1597.8043  274.3916      . .

4     0.050  235.0781 1673.4376  232.2152  316.5659 1607.9659  219.6344  144.7652 1597.5711  274.4420      . .

5     0.067  235.0781 1673.4376  232.2152  316.7533 1608.3785  218.5500  144.7296 1597.8043  274.3916      . .

6     0.083  235.0781 1673.4376  232.2152  316.2800 1608.3460  219.1676  144.7963 1597.3691  274.4994      . .

7     0.100  235.3844 1673.4179  232.3085  316.4539 1608.1409  219.6402  144.7963 1597.3691  274.4994      . .

8     0.117  235.1416 1673.4447  232.4143  316.4539 1608.1409  219.6402  145.1222 1597.3621  274.3569      . .

9     0.133  235.4312 1673.4882  232.7111  316.1265 1608.1984  219.7480  144.7963 1597.3691  274.4994      . .

10    0.150  236.0334 1673.4269  233.0335  315.9777 1608.3370  220.0773  144.6867 1597.5786  274.4743      . .

11    0.167  235.7562 1673.7265  233.4352  316.4172 1608.1043  219.9638  144.7963 1597.3691  274.4994      . .

12    0.183  235.5336 1673.4414  233.5973  315.9770 1608.0798  220.2932  144.7963 1597.3691  274.4994      . .

. . .. . .    . . .     . . .     . . .     . . .     . . .     . . .     . . .     . . .     . . .      . .
```

HTR2—Hierarchical Translations and Rotations

The HTR2 (***.htr2**) file contains rotations (about X, Y and Z axis) for the body segments defined in the **EVaRT** Project and translations and rotations for the root segment. Rotations are calculated relative to a local coordinate system of each segment’s designated parent.

The HTR files translation are expressed in the units used for **EVaRT** system calibration and the rotations are calculated as Euler angles expressed in degrees. These Euler angles are either bounded or continuous.

- **Bounded**—indicates that when the angles are extracted they are bounded or constrained between ± 180 degrees for the X and Z directions, and ± 90 degrees for the Y direction.
- **Continuous**—means that the angles will be continuous, i.e. the angles are not bounded. With unbounded angles you can conceivably have an angle that goes from 0 to 1,000 degrees for each one of the X,Y and Z angles.

This HTR file has four main parts: the Header; the Segment Names and Hierarchies, the Base Position, and the Data.

Typically, the Base Position frame is selected when the subject’s body is in a symmetrically oriented, neutral stance position. This Base Position frame is very important because this will be the position and orientation where each segment’s translation and rotation is set to zero and the bone length scale factor is set to 1.0.

Since all segments are hierarchical, child segments have their translations and rotations relative to their parent. The origin of a child segment is found by applying the translations relative to the parent’s coordinate system. The orientation of the child segment can be established by rotating the child’s coordinate system relative to the parents coordinate system about each of the axes.

In the data section, the order of transformation is: translation followed by rotation. The segment names are keywords, for example **head.** Each segment’s data is contained in seven columns, translations in X, Y and Z, rotations about X, Y and Z and a scale factor for the Y axis or bone length. Each frame of data is represented on one row.

Example

The complete file contains data for each of the 20 segments. The position of each segment is recorded for 387 video frames. Such a file is quite large, so we have included an abbreviated version here.

The file begins with a **[Header]** section containing general information, such as the number of segments, the number of frames, the frame rate, and other parameters which apply to all data in the file.

This is followed by the **[SegmentNames&Hierarchy]** section which describes the child-parent relationships of the skeleton. Notice that only the **LowerTorso** segment relates to the **GLOBAL** coordinate system. All other segments motions are described in relation to a parent segment.

In the **[BasePosition]** section, the location of each segment’s origin and rotation are described in the skeleton’s base position, using the six available degrees of freedom:

Translation in X	**Rotation about X axis**
Translation in Y	**Rotation about Y axis**
Translation in Z	**Rotation about Z axis**

For the child segments, location and rotation are given in terms of the parent. In this skeleton, the origin of all the children lie near the bone (Y axis) of the parent and, therefore, have only Y values. The seventh column gives the length of the bone segment.

The remaining sections contain motion data for each segment, in each frame, relative to the base position. This is frame oriented, meaning each section holds all segments for that particular frame.

In this abbreviated example, only the first and last four frames are shown for the first three segments. In the actual file, all 387 frames for each of the 20 segments would appear. After all the segments, an **[EndOfFile]** section terminates the file.

Figure G-3. An Example of an HTR2 File

```
# Hierarchical Translation and Rotation (.htr) file
# Generated by EVaRT
[Header]
FileType htr
DataType HTRS
FileVersion 2
NumSegments 20
NumFrames 511
DataFrameRate 60
EulerRotationOrder ZYX
CalibrationUnits mm
RotationUnits Degrees
GlobalAxisofGravity Y
BoneLengthAxis Y
ScaleFactor 1
[SegmentNames&Hierarchy]
#CHILD            PARENT
Head              Neck
Neck              UpperTorso
UpperTorso        LowerTorso
LCollarBone       UpperTorso
RCollarBone       UpperTorso
LUpArm            LCollarBone
RUpArm            RCollarBone
LLowArm           LUpArm
RLowArm           RUpArm
LHand             LLowArm
RHand             RLowArm
LowerTorso        GLOBAL
LPelvis           LowerTorso
RPelvis           LowerTorso
LThigh            LPelvis
RThigh            RPelvis
LLowLeg           LThigh
RLowLeg           RThigh
LFoot             LLowLeg
RFoot             RLowLeg
[BasePosition]
#SegmentName      Tx   Ty   Tz   Rx   Ry   Rz   BoneLength
Head              0.0  0.0  0.0  0.0  0.0  0.0  1.0
Neck              0.0  0.0  0.0  0.0  0.0  0.0  1.0
UpperTorso        0.0  0.0  0.0  0.0  0.0  0.0  1.0
LCollarBone       0.0  0.0  0.0  0.0  0.0  0.0  1.0
RCollarBone       0.0  0.0  0.0  0.0  0.0  0.0  1.0
LUpArm            0.0  0.0  0.0  0.0  0.0  0.0  1.0
RUpArm            0.0  0.0  0.0  0.0  0.0  0.0  1.0
LLowArm           0.0  0.0  0.0  0.0  0.0  0.0  1.0
RLowArm           0.0  0.0  0.0  0.0  0.0  0.0  1.0
LHand             0.0  0.0  0.0  0.0  0.0  0.0  1.0
RHand             0.0  0.0  0.0  0.0  0.0  0.0  1.0
LowerTorso        0.0  0.0  0.0  0.0  0.0  0.0  1.0
LPelvis           0.0  0.0  0.0  0.0  0.0  0.0  1.0
RPelvis           0.0  0.0  0.0  0.0  0.0  0.0  1.0
LThigh            0.0  0.0  0.0  0.0  0.0  0.0  1.0
RThigh            0.0  0.0  0.0  0.0  0.0  0.0  1.0
LLowLeg           0.0  0.0  0.0  0.0  0.0  0.0  1.0
RLowLeg           0.0  0.0  0.0  0.0  0.0  0.0  1.0
LFoot             0.0  0.0  0.0  0.0  0.0  0.0  1.0
RFoot             0.0  0.0  0.0  0.0  0.0  0.0  1.0
#Beginning of Data.
```

```
Frame 1:
   0:    265.65848    958.52289    171.77657
   1:     -5.56661     -1.03833     -3.08909    222.84282
   2:      6.64226    -10.44067     -1.80951     81.65315
   3:     -5.68993     -4.37941      2.25734    279.37607
   4:      0.21077      8.22242   -101.23232    148.15902
   5:     -2.91121    -14.64063     98.93079    122.55443
   6:      7.62039      4.41526      6.57253    286.27760
   7:      4.45230      6.92158     -1.13849    273.89803
   8:      0.27224      1.42203      2.06549    197.27960
   9:     10.70936      0.37209     -6.77907    227.77268
  10:      5.60677      0.99909     -5.37607    160.71960
  11:     -7.93797     -1.63432      4.66433    138.17473
  12:      7.92266      6.08590      0.69348    116.27502
  13:     17.83143      2.88770   -106.49151    122.39289
  14:      5.29669      4.26448    108.76140    124.66989
  15:      3.41580    -26.21330    -60.12212    448.80791
  16:      0.59471     18.20674     59.84934    469.08647
  17:     -6.65161     -0.51561     -9.07148    349.00357
  18:     -8.69699      2.51242      6.54966    359.40872
  19:     56.16376     -3.45440      1.11591    184.70566
 20:     69.34235      4.62345     -3.69895    181.04145

Frame 2:
   0:    265.98917    958.55890    171.80534
   1:     -4.76026     -0.93315     -1.37413    222.40665
   2:      6.24591    -10.44039     -3.43725     81.65838
   3:     -5.45918     -4.48315      2.16439    279.15316
   4:      0.25053      8.10135   -101.08283    148.41689
   5:     -2.74117    -14.49931     99.00355    122.50407
   6:      7.56453      4.56852      6.41734    286.17036
   7:      4.44328      6.91024     -1.35979    273.86227
   8:      0.13121      1.30640      2.05696    196.92114
   9:     10.54723      1.02512     -6.42520    227.48704
 10:      6.09020      1.13973     -5.56063    160.93207
  11:     -7.83955     -2.10847      4.52455    138.30477
  12:      7.76307      6.08555      0.77588    116.44541
  13:     17.85974      3.07533   -106.59285    122.55485
  14:      5.44536      3.99245    108.62376    124.97174
  15:      3.05847    -26.22045    -60.08476    448.35952
  16:      0.34028     16.47090     59.49600    468.76412
  17:     -6.65867     -0.44105     -9.10057    349.54976
  18:     -8.45317      4.60744      7.28953    359.82323
  19:     56.25188     -3.41367      1.03058    184.85654
  20:     69.34779      4.49733     -4.24123    181.27314

             .....

             .....

[EndofFile]
```

HTR

HTR files provide the same information as HTR2 files, but in a segment oriented method which is less suitable for information streaming. Refer to "HTR2—Hierarchical Translations and Rotations" on page G-5. The HTR format cannot created in **EVaRT**. This feature will be added to future revisions.

Examples of HTR Files

Information about the structure and motion of hierarchical skeletons is stored in **.htr** files. There are two variations of **.htr** files: version 1 (HTR) and version 2 (HTR2). The skeleton data is identical in both file versions, however, the motion data is presented on a segment basis in version 1 files, while it is on a frame basis in version 2 files. Thus, version 1 files give the position data for all frames for the first segment followed by the position data for all frames for the second segment, etc. HTR Version 1 files are used:

1. to save as HTR in **EVaRT** under the Post Skeleton function in the Tools menu
2. for input and output from **Si 2.0**
3. for input and output for many of the animation package software

HTR2 files are output from steaming mode from **EVaRT 3.0** and **EVaRT**, but there is no software to import them. Version 2 file gives the position data for all segments for the first video frame followed by the position data for all segments for the second frame, etc.

Example of an HTR Version 1 File

The example of a version 1 file shown in Figure G-4 on page G-11 was generated by Motion Analysis **MoCap Solver** and contains data for the movement of a hierarchical skeleton with one root and 19 child segments. Since the file was generated by **MoCap Solver**, the skeleton has fixed length bones.

The complete file contains data for each of the 20 segments. The position of each segment is recorded for 196 video frames. Such a file is quite large, so we have included an abbreviated version here.

The file begins with a **[Header]** section containing general information, such as the number of segments, the number of frames, the frame rate, and other parameters which apply to all data in the file.

This is followed by the **[SegmentNames&Hierarchy]** section which describes the child-parent relationships of the skeleton. Notice that only the **LowerTorso** segment relates to the GLOBAL coordinate system. All other segments motions are described in relation to a parent segment.

In the **[BasePosition]** section, the location of each segment's origin and rotation are described in the skeleton's base position, using the six available degrees of freedom:

Translation in X	Rotation about X axis
Translation in Y	Rotation about Y axis
Translation in Z	Rotation about Z axis

For the child segments, location and rotation are given in terms of the parent. In this skeleton, the origin of all the children lie on the bone (Y axis) of the parent and, therefore, have only Y values. The seventh column gives the length of the bone segment.

The remaining sections contain motion data for each segment relative to the base position. Each section starts with the segment name followed by position data and the scale factor (SF) for each frame. The first segment, **[LowerTorso]**, is unique because it has six values describing its relation to the global coordinate system. All subsequent segments have only three rotational degrees of freedom. Therefore, if you wished to find the global coordinates of any segment in any frame you would follow these steps:

- Calculate the three rotation values for each segment using the values from the desired frame and the base position for that segment. For the root, also calculate each of the three translation values. Be careful to use the correct rotation order as indicated in the header of the **.htr** file.
- Using the positions and rotation of the root segment as a starting point, calculate the global positions of the origin of the first child's coordinate system in the hierarchy.
- Using this calculated global position, calculate the global position of the origin of the next child's coordinate system.
- Continue until you have reached the desired segment.

In the abbreviated example shown in Figure G-4, only the first and last four frames are shown for the first three segments. In the actual file, all 196 frames for each of the 20 segments would appear. After all the segments, an **[EndOfFile]** section terminates the file.

Example of a HTR2 File

The example of a HTR2 file shown in Figure G-5 on page G-14 was generated using Motion Analysis **SkB** and therefore does not have fixed bone lengths.

The information in the **[Header]**, **[SegmentName&Hierarchy]**, and **[BasePosition]** is very similar to the first example. However, note that the **FileVersion** is **2** instead of **1**. Also, notice that the use of scale factor and bone lengths are reversed from the usage in version 1 files. The bone lengths given in the base position are all 1.0. The actual bone length for each segment in each frame is given in the data section.

The data section starts at frame 1. The segment data is then given in the order defined in the **[SegmentNames&Hierarchy]** section. Segment 0 is the X, Y, and Z translation values for the root segment. The four values for each remaining segment are the X, Y, and Z rotations in degrees and the bone length in calibration units.

There is no end of file section, since the number of frames is already defined under **NumFrames** in the **[Header]** section.

Figure G-4. An Example of a HTR (Version 1) File

```
[Header]                # Header keywords are followed by a single value
FileType htr            # single word string
DataType HTRS           # Hierarchical translations followed by rotations and Scale
FileVersion 1           # integer
NumSegments   20        # integer
NumFrames   196         # integer
DataFrameRate    30     # integer
EulerRotationOrder XYZ  # one word string
CalibrationUnits mm     # one word string
RotationUnits Degrees   # one word string
GlobalAxisofGravity Y   # character, X or Y or Z
BoneLengthAxis Y
ScaleFactor 1.0000

[SegmentNames&Hierarchy]
#CHILD         PARENT
LowerTorso     GLOBAL
UpperTorso     LowerTorso
LCollarBone    UpperTorso
RCollarBone    UpperTorso
LUpArm         LCollarBone
RUpArm         RCollarBone
LLowArm        LUpArm
RLowArm        RUpArm
LHand          LLowArm
RHand          RLowArm
LPelvis        LowerTorso
RPelvis        LowerTorso
LThigh         LPelvis
RThigh         RPelvis
LLowLeg        LThigh
RLowLeg        RThigh
LFoot          LLowLeg
RFoot          RLowLeg
Neck           UpperTorso
Head           Neck




[BasePosition]

#SegmentName Tx, Ty,    Tz,         Rx,        Ry,       Rz,        BoneLength

LowerTorso238.320832923.726971241.2948288.8069650.0000002.422863 141.720766

UpperTorso0.000000141.7207660.000000-9.396187-0.112582-0.4.226674324.970754

LCollarBone0.000000324.9707540.000000-8.9120410.520925-117.992062155.689602

RCollarBone0.000000324.9707540.000000-7.516124-0.516778118.838556127.553756

LUpArm 0.000000155.6896020.000000  11.284636  -3.556895 24.261557  273.483757

RUpArm 0.000000127.5537560.000000  12.990029  2.960321  -24.250841 285.322188

LLowArm0.000000273.4837570.000000  -15.450962 -0.327390 -5.501311  318.246332

RLowArm0.000000285.3221880.000000  -12.465152 -0.572074 -5.115813  305.910223

LHand  0.000000318.2463320.000000  10.682556  -5.620492 27.438027  85.440039

RHand  0.000000305.9102230.000000  5.730878   2.097665  -20.038204 98.351413

LPelvis0.0000000.000000 0.000000   24.672467  -6.972213 -127.877478122.309825

RPelvis0.0000000.000000 0.000000   39.808415  6.985094  127.739824 133.924520

LThigh 0.000000122.3098250.000000  -12.585726 -15.440180-52.153190388.012318
```

```
#Beginning of Data. Separated by tabs

[LowerTorso]
#Fr    Tx     Ty        Tz        Rx         Ry        Rx         SF
1      1262.497925-15.182068-2245.4418950.5336240.713565-1.0697651.000000
2      1262.534546-15.109411-2245.4282230.5902200.697084-1.1088881.000000
3      1262.367920-15.051557-2245.3151860.5882480.707301-1.1631961.000000
4      1261.811279-15.027791-2245.1335450.6069780.696131-1.3261221.000000
. . . . . . . .
. . . . . . . .
. . . . . . . .
193    -25.763012-11.505680-116.749229-85.78657582.456894-104.4607321.000000
194    -31.705627-12.149048-131.977005-81.80329980.946663-100.7663191.000000
195    -40.086079-12.445135-144.204391-77.85765879.605011-97.4399491.000000
196    -49.986629-12.544500-152.518951-74.27449278.596512-94.2411671.000000

[UpperTorso]
#Fr    Tx     Ty        Tz        Rx         Ry        Rx         SF
1      0.0000000.000000 0.000000  -2.259649  -2.946399 -0.475843 1.000000
2      0.0000000.000000 0.000000  -2.341502  -2.767608 -0.420984 1.000000
3      0.0000000.000000 0.000000  -2.331526  -2.552349 -0.414928 1.000000
4      0.0000000.000000 0.000000  -2.328715  -2.410058 -0.305621 1.000000
. . . . . . . .
. . . . . . . .
. . . . . . . .
193    0.0000000.000000 0.000000  2.688713   -0.354111 4.239368  1.000000
194    0.0000000.000000 0.000000  0.312819   -2.503460 6.899297  1.000000
195    0.0000000.000000 0.000000  -1.617305  -3.427358 9.416446  1.000000
196    0.0000000.000000 0.000000  -2.357207  -3.057341 10.941742 1.000000

[LCollarBone]
#Fr    Tx     Ty        Tz        Rx         Ry        Rx         SF
1      0.0000000.000000 0.000000  2.648904   1.239630  0.547259  1.000000
2      0.0000000.000000 0.000000  2.753487   1.291442  0.549240  1.000000
3      0.0000000.000000 0.000000  2.832925   1.339503  0.493109  1.000000
4      0.0000000.000000 0.000000  2.839463   1.330919  0.571445  1.000000
. . . . . . . .
. . . . . . . .
. . . . . . . . .
193    0.0000000.000000 0.000000  2.837519   0.820427  3.997483  1.000000
```

```
194    0.0000000.000000 0.000000   1.948793   0.402037  3.829116   1.000000

195    0.0000000.000000 0.000000   1.872437   0.383394  3.696403   1.000000

196    0.0000000.000000 0.000000   2.747322   0.820163  3.692526   1.000000


. . . . . . . .

. . . . . . . .

. . . . . . . .

. . . . . . . .



[EndOfFile]
```

Figure G-5. An Example of a HTR2 File

```
 Hierarchical Translation and Rotation (.htr) file
# Generated by EVaRT
[Header# Header keywords are followed by a single value
FileType htr# single word string
DataType HTRS# Hierarchical translations followed by rotations and Scale
FileVersion 2# integer
NumSegments 20# integer
NumFrames 511       # integer
DataFrameRate 60# integer
EulerRotationOrder ZYX# one word string
CalibrationUnits mm# one word string
RotationUnits Degrees# one word string
GlobalAxisofGravity Y# character, X or Y or Z
BoneLengthAxis Y
ScaleFactor 1

[SegmentNames&Hierarchy]
#CHILDPARENT
HeadNeck
NeckUpperTorso
UpperTorsoLowerTorso
LCollarBoneUpperTorso
RCollarBoneUpperTorso
LUpArmLCollarBone
RUpArmRCollarBone
LLowArmLUpArm
RLowArmRUpArm
LHandLLowArm
RHandRLowArm
LowerTorsoGLOBAL
LPelvisLowerTorso
RPelvisLowerTorso
LThighLPelvis
RThighRPelvis
LLowLegLThigh
RLowLegRThigh
LFootLLowLeg
RFootRLowLeg
[BasePosition]
#SegmentNameTxTyTz Rx Ry RzBoneLength
Head 0.0 1.0 0.0 0.0 0.0 0.0 1.0
Neck  0.0 1.0 0.0 0.0 0.0 0.0 1.0
UpperTorso  0.0 1.0 0.0 0.0 0.0 0.0 1.0
LCollarBone  0.0 1.0 0.0 0.0 0.0 0.0 1.0
RCollarBone  0.0 1.0 0.0 0.0 0.0 0.0 1.0
LUpArm  0.0 1.0 0.0 0.0 0.0 0.0 1.0
RUpArm  0.0 1.0 0.0 0.0 0.0 0.0 1.0
LLowArm  0.0 1.0 0.0 0.0 0.0 0.0 1.0
RLowArm 0.0 1.0 0.0 0.0 0.0 0.0 1.0
LHand  0.0 1.0 0.0 0.0 0.0 0.0 1.0
RHand  0.0 1.0 0.0 0.0 0.0 0.0 1.0
LowerTorso  0.0 0.0 0.0 0.0 0.0 0.0 1.0

LPelvis  0.0 0.0 0.0 0.0 0.0 0.0 1.0
```

ANC—Analog ASCII Row Column

ANC (**.anc**) files contain ASCII analog data in row-column format. The data is derived from ***.anb** analog binary files. These binary ***.anb** files are generated simultaneously with video ***.vc** files if an optional analog input board is used in conjunction with video data capture.

To create an ***.anc** file from an ***.anb** file, from the main menu select **File > Export ANC**. The data in ANC files is raw analog data in ASCII form and can be read and manipulated by a spreadsheet program.

Shown in Figure G-6 is the beginning portion of an ***.anc** file.

Figure G-6. Example of an ANC File

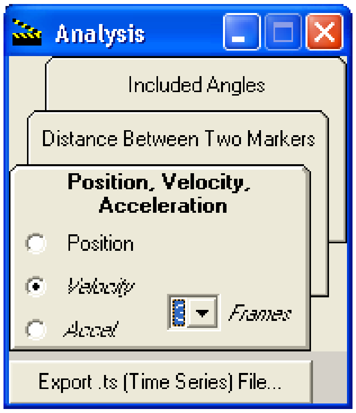
```
File_Type:  Analog R/C ASCII        Generation#:1
Board_Type: National AT-MIO-64F-5   Polarity:Bipolar
Trial_Name:1ndbfw Trial#: 8         Duration(Sec.): 6.000000#Channels:30

Name      f1x   f1y   f1z   m1x   m1y   m1z   f2x   f2y   f2z   m2x   m2y  m2zL tibialis
ant
Rate     1000  1000  1000  1000  1000  1000  1000  1000  1000  1000  1000  1000  1000
Range   10000 10000 10000 10000 10000 10000 10000 10000 10000 10000 10000 10000  2500
0.0000      0     1   -29    -1    -2     0    -1     0   -13     2     3   -11  -550
0.0010     -1     0   -29    -1    -2     0    -2    -1   -13     1     2   -10  -392
0.0020     -1     0   -29    -1    -3     0    -2    -1   -13     1     2   -10  -369
0.0030     -1     0   -29    -2    -3     0    -1    -1   -13     1     2   -10  -440
0.0040      0     0   -29    -1    -2     0    -2    -1   -13     1     3   -10  -342
0.0050      1     1   -29    -1    -2    -1    -2     0   -13     1     3   -11  -531
0.0060      0     0   -29    -1    -2     0    -2    -1   -13     1     3   -11  -803
0.0070      0     0   -28    -1    -2     0    -2    -1   -12     1     3   -10  -738
0.0080      0     0   -28    -1    -2     0    -2    -1   -13     1     2   -10  -485
0.0090      0     1   -28    -1    -2     1     0     0   -12     2     3   -10   453
0.0100      0     0   -28    -1    -2     0    -1     0   -12     2     4   -10   876
0.0110      0     0   -29     0    -2     0    -1    -1   -13     1     3   -10  1401
0.0120      0     1   -29    -1    -2     0    -1    -1   -13     1     2   -10   598
0.0130     -2    -1   -30    -3    -3     0    -3    -3   -13     0     2   -10  -141
0.0140      0     0   -29    -1    -2     0    -2    -1   -13     2     2   -11  -457
0.0150      0     0   -28    -1    -2     0    -2    -1   -13     2     3   -10   446
0.0160      0     0   -29    -1    -2     0    -1    -1   -13     1     2   -11   569
0.0170      0     0   -28    -1    -2     0    -1    -1   -13     1     3   -10   507
0.0180     -1     0   -29    -1    -2     0    -2    -1   -13     2     3   -10   689
0.0190      0     0   -29    -2    -2     0    -2    -2   -12     1     2   -10   501
0.0200     -1     0   -29    -1    -2     0    -2    -1   -13     1     2   -10   348
0.0210     -1     0   -29     0    -2     0    -1    -1   -13     1     3   -11   209
```

TS—Time Series Files from the EVaRT Analysis Functions: Velocity and Acceleration Calculations

EVaRT Analysis Functions (F7) is a selectable view from the Data Views menu and allows the user to calculate velocity and accelerations of marker data, distances between markers and Included Angles. The Distances and Included angles are assumed to be self-documenting and a description of the Position, Velocity and Acceleration tabs is below. These data can be Exported to the .ts (Time Series) files.

Figure G-7. Analysis Functions


Analysis
Included Angles
Distance Between Two Markers
Position, Velocity, Acceleration
○ Position
● Velocity
○ Accel
Frames
Export .ts (Time Series) File...

There is a Frames Factor, which can be set to 3, 5, 7, or 9 frames. This selects the number of frames to use for the velocity and acceleration calculations. If the Frames Factor is set to 3 frames, velocity data for the 5-th frame is calculated exclusively from frame 4 and frame 6. Velocity Data for frame 1 does not exist; velocity and frame data starts at frame 2. If the Frame Factor is set to 5, the velocity data comes exclusively from –2 frames to +2 frames from the i-th frame. Larger Frame Factors have the effect of smoothing the data.

X1, Y1, Z1 Positional data is determined from the marker locations.

Velocity Calculation is done with a central difference. Let FR represent the Frame Rate of the camera. Time difference between frames = 1 / FR in the below calculations.

Velocity Calculation for frame i with a Frames Factor of 3:

$$vX1(i) = FR^{*}(X(i+1) - X(i-1)) / 2$$
$$vY1(i) = FR^{*}(Y(i+1) - Y(i-1)) / 2$$
$$vZ1(i) = FR^{*}(Z(i+1) - Z(i-1)) / 2$$

Velocity Calculation for frame i with a Frames Factor of 5:

$$vX1(i) = FR^{*}(X(i+2) - X(i-2)) / 4$$
$$vY1(i) = FR^{*}(Y(i+2) - Y(i-2)) / 4$$
$$vZ1(i) = FR^{*}(Z(i+2) - Z(i-2)) / 4$$

Velocity Calculation for frame i with a Frames Factor of 7:

vX1 (i) = FR* (X (i+3) - X (i-3)) / 6
vY1 (i) = FR* (Y (i+3) - Y (i-3)) / 6
vZ1 (i) = FR* (Z (i+3) - Z (i-3)) / 6

Velocity Calculation for frame i with a Frames Factor of 9:

vX1 (i) = FR* (X (i+4) - X (i-4)) / 8
vY1 (i) = FR* (Y (i+4) - Y (i-4)) / 8
vZ1 (i) = FR* (Z (i+4) - Z (i-4)) / 8

Resultant velocity scalar:

vR1 (frame i) = SQRT(vX1**2 + vY1**2 + vZ1**2)

Accelerations for Frame i are calculated as the differences in velocity as:

A (frame i) = Velocity (frame I >frame i+1) - Velocity (frame i-1 >frame i)

Time difference between frames = 1/ FR .

Acceleration Calculations sing the Frame Rate (FR) of the camera for a Frames Factor of 3:

aX1 (i) = FR*FR* (X (i+1) - 2* X(i) + X (i-1))
aY1 (i) = FR*FR* (Y (i+1) - 2* Y(i) + Y (i-1))
aZ1 (i) = FR*FR* (Z (i+1) - 2* Z(i) + Z (i-1))

For Frames Factor of 5:

aX1 (i) = FR*FR* (X (i+2) - 2* X(i) + X (i-2)) / 4
aY1 (i) = FR*FR* (Y (i+2) - 2* Y(i) + Y (i-2)) / 4
aZ1 (i) = FR*FR* (Z (i+2) - 2* Z(i) + Z (i-2)) / 4

For Frames Factor of 7:

aX1 (i) = FR*FR* (X (i+3) - 2* X(i) + X (i-3)) / 9
aY1 (i) = FR*FR* (Y (i+3) - 2* Y(i) + Y (i-3)) / 9
aZ1 (i) = FR*FR* (Z (i+3) - 2* Z(i) + Z (i-3)) / 9

For Frames Factor of 9:

aX1 (i) = FR*FR* (X (i+4) - 2* X(i) + X (i-4)) / 16
aY1 (i) = FR*FR* (Y (i+4) - 2* Y(i) + Y (i-4)) / 16
aZ1 (i) = FR*FR* (Z (i+4) - 2* Z(i) + Z (i-4)) / 16

Resultant acceleration scalar:

aR1 (frame i) = SQRT(aX1**2 + aY1**2 + aZ1**2)

Binary Files—ANB, TRB, and C3D

The following are binary files and cannot be directly read or manipulated by the end user. Their function and context are briefly described.

ANB

These files contain up to 64 channels of analog data collected simultaneously with video data by the optional analog board. The data in these files can be converted to readable ASCII form as either an ANA or ANC file. To do so, from the main menu select **File > Export ANC.**

Note: The data contained in the ***.anb** file has a dynamic range of –2048 to +2047, which represents 12 bit signed numbers. **EVaRT** scales the specified input voltage range to this range of values.

TRB

These files contain the same 3D track data as ASCII **.trc** files, saved in a compact binary form. In addition to the data in **.trc** files, **.trb** files contain the following data for each frame:

- a list of the cameras used to calculate the 3D marker position
- the residual of the 3D position calculation

C3D

These are a special binary files that contains both scaled 3D track data and unscaled analog data. For more information, you can visit the C3D website at www.c3d.org.

Appendix H SIMM Motion Module

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Introduction

The Motion Module is an optional component to SIMM (Software for Interactive Musculoskeletal Modeling) that allows you to easily import data recorded by a motion capture system. It reads files containing tracked marker data (3D positions of markers in global space) using the TRC or TRB file format developed by Motion Analysis Corporation. It can also read analog files in the ANB or ANC format with ground-reaction force and EMG data that was recorded in sync with the motion. The Motion Module can also read C3D files, which contain both tracked marker and analog data in the same file. Additionally, the real-time version of the Motion Module can connect to a Motion Analysis system and receive and display motion and analog data in real-time, as it is being recorded.

Files of tracked marker data contain a sequence of frames, each representing a snapshot of the subject’s motion at a particular instant in time. Each frame contains the X, Y, and Z coordinates, expressed in a global coordinate system, of all the identified markers. A frame of marker data can thus be thought of as a “marker cloud” because the coordinates are not organized by body segment.

The Motion Module imports tracked marker data and fits a SIMM model within the marker cloud for each time frame. If the SIMM model contains markers whose names and positions match those of the markers placed on the subject, the Motion Module can adjust the model’s gencoord values to determine a “best fit” of the model to the marker cloud. The quality of a fit is determined by how closely each of the model’s markers is to its corresponding marker in the marker cloud. It then uses this best fit as the starting position for solving the next frame of data. The result is a SIMM motion that matches the tracked marker data. The model that is used to fit the data can either be one that you create or the pre-made model (the *mocap model*) that comes with the Motion Module.

The Motion Module has two primary components. The first component reads files containing tracked marker data (in the TRC, TRB, or C3D format) and creates SIMM motions from them, as described above. For more information on how this process works, and the various options for importing marker data, reference the *SIMM User’s Guide*.

The second component of the Motion Module creates a musculoskeletal model of a given individual by scaling a generic full-body model (the *mocap model*) based on tracked marker data from a static pose. The algorithms that are used to scale the model are the same as those used in OrthoTrak, a full-body gait analysis package available from Motion Analysis. For more information on the mocap model and how it is created and used, see Section 5.3, Using the Mocap Model.

Opening Tracked Marker Files

SIMM can import tracked marker data that is stored in either a TRB or TRC data file. These file formats, described in the **EVa** and **EVaRT** manuals, contain X, Y, and Z coordinates for each identified marker for each time frame. You can also import analog data files containing forceplate and EMG data recorded during the motion. These analog data files can be in either the ANB or ANC formats. The Motion Module can also read XLS files containing other motion-related data that you may want to view in SIMM, such the kinetic data contained in an OrthoTrak single trial spreadsheet. For more information on importing analog and XLS files, see Section 5.2.3, Analog Data.

The Motion Module can also read C3D data files. These files contain tracked marker and analog data in the same file, so you only need to load one file to import all of your motion data from a trial.

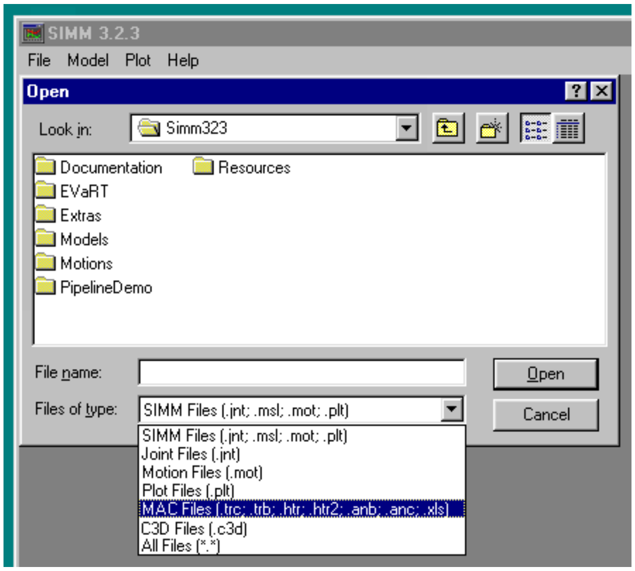
When you open a tracked marker file (along with any associated analog files), SIMM attempts to map the data onto the current musculoskeletal model, thus creating a SIMM motion that is linked to the model. Therefore, to open a tracked marker file, you must already have loaded into SIMM a model that contains the same marker set used in the marker file. For best results, you should make sure that every marker in the tracked marker file is also in the SIMM model, and that their locations in the SIMM model match where they were placed on the subject. The marker names should match exactly (except that they are case-insensitive). If the file contains markers that are not in the model, their data will be ignored by the Motion Module. Similarly, if the model contains markers that are not in the file, they will not be used to help fit the model to the motion data.

If you need to add, rename, or move markers in your SIMM model before loading a tracked marker file, you can use the Marker Editor to do so. See Section 2.12, Marker Editor, for more details.

Selecting Tracked Marker Files

To import a tracked marker file into SIMM, first make sure that the model you want to apply it to is the current model (the topmost window in SIMM). Then select **File > Open** from the menu bar. When the Windows® file browser appears, change the Files of Type popup menu at the bottom of the browser to **MAC Files** or to **C3D Files** then navigate to the folder containing the tracked marker file[s] you want to import.

Figure H-1. Windows File Browser


SIMM 3.2.3
File
Model
Plot
Help
Open
Look in:
Simm323
Documentation
Resources
EVaRT
Extras
Models
Motions
PipelineDemo
File name:
Files of type:
SIMM Files (.jnt; .msl; .mot; .plt)
Open
Cancel
SIMM Files (.jnt; .msl; .mot; .plt)
Joint Files (.jnt)
Motion Files (.mot)
Plot Files (.plt)
MAC Files (.trc; .trb; .htr; .htr2; .anb; .anc; .xls)
C3D Files (.c3d)
All Files (*.*)

Next, select the appropriate marker file[s] in the file browser. Click the **Open** button to import the file[s]. At this point SIMM will display a dialog box allowing you to specify several options for importing each data file into SIMM.

Note: If your analog data files have the same base name as your TRB/TRC file (*e.g.*, **subject14.trc, subject14.anb, and subject14.xls**), then it is not necessary to select analog files in the file browser. SIMM will automatically open any analog or XLS files with the same base name and in the same folder as the tracked marker file (there is an option in the dialog box to turn off this feature). If you are loading C3D files, this is not an issue since all of the data for the motion are stored in the C3D file.

Tracked Marker Options Dialog

Once you have selected one or more tracked marker files using the process described in the previous section, SIMM displays a dialog box for each one (in sequence), allowing you to set some options for importing the marker data. In many cases, you will want to use the default settings for these options, so you can simply click the **OK** button to import the motion. The following list describes each option in the dialog box.

Import Frames, To, Increment

These fields allow you to specify the range of frames to read from the marker file, as well as the increment. To use them, type into the first two fields the starting and ending frame numbers that you want to import. The third field specifies the increment to use when reading frames from the file. For example, to read every other frame from the file, enter an increment of 2. The starting frame number field and the increment field are initialized to 1. The ending frame number is initialized to the number of frames in the marker file.

Quick Solve

The Motion Module contains two optimization algorithms for fitting the musculoskeletal model to the marker data. The default method is fairly robust- it is designed to handle cases in which several markers are missing from a frame or in which the markers move large amounts between frames. The other method, called quick solve, is less robust but works up to twice as fast as the default method. If speed is an issue, and you know that your marker data is well-behaved, you may want to turn this option on to use the faster optimization algorithm.

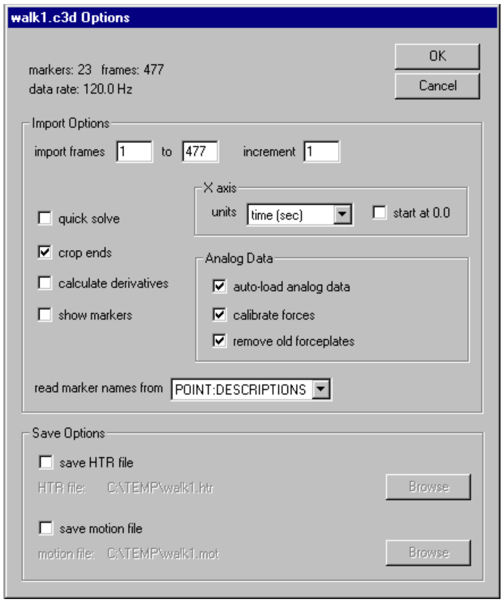
Crop Ends

Tracked marker data files often have frames at the beginning and end of a motion that are missing some markers (because the subject is outside the camera volume). To automatically detect and ignore these frames as the file is read, turn on this option (it is on by default). When the option is on, SIMM will start at the first frame and delete it if it is missing one or more markers. It will then continue to scan forward through the frames, deleting each one, until it encounters a frame containing all of the markers. It will then do the same procedure starting at the last frame and working backwards. SIMM will not remove frames with missing markers that are in between full frames, so there may still be frames in the motion that are missing markers.

Calculate Derivatives

When loading a motion, SIMM has the capability of calculating derivatives of the motion variables. When this option is turned on, after SIMM has solved the marker data and created a SIMM motion, it will calculate first-order time derivatives of the generalized coordinate values (*i.e.*, joint velocities) during the motion. It will also calculate derivatives of any force or EMG data in the analog file (if present). These derivatives can then be plotted using the Motion Curves command in the Plot Maker (see Section 2.5.2 for more details).

Figure H-2. Tracked Marker Import Dialog Box



markers: 23 frames: 477
data rate: 120.0 Hz

import frames 1 to 477 increment 1

units time (sec) ☐ start at 0.0

☐ quick solve
☑ crop ends
☐ calculate derivatives
☐ show markers

☑ auto-load analog data
☑ calibrate forces
☑ remove old forceplates

read marker names from POINT:DESCRIPTIONS

☐ save HTR file
HTR file: C:\TEMP\walk1.htr

☐ save motion file
motion file: C:\TEMP\walk1.mot

Show Markers

This checkbox turns on the display of the global marker positions in each frame when playing back a motion. When it is on, SIMM will add spherical motion objects to the motion, representing the location of each marker, as recorded in the marker file. When you animate the model according to the motion, the blue spheres represent these actual, recorded marker locations. These are the marker locations that the Motion Module is trying to fit the model to, for each frame. It can be helpful to display them in the model window in order to visualize how good the fit is, and to help debug problems with the data.

X Axis Units, Start at Zero

These options give you control over the specification of the X axis of the motion that is created from the marker data. The units along the X axis can be either time (in seconds), or frame number. The starting X value of the motion will be 0.0 if the units are time, and 1 if the units are frame number, unless frames of data are cropped because of missing markers (see "Crop Ends" on page H-4). For example, if 12 frames of data are cropped from the beginning of the motion (and the data frequency is 60 Hz), the starting X value will be 0.2 seconds for units of time, and 13 for units of frame number. If you want the X values to start at 0.0 (or 1 for frame number) even if frames are cropped, turn on the start at zero option.

Auto-Load Analog Data

When this box is checked, SIMM will look for and automatically load any analog (ANB, ANC) or XLS data files with the same base name as the TRB/TRC file. If SIMM did not detect the presence of any analog files when the TRB/TRC file was selected, this option is grayed out.

If you selected a C3D file with the file browser, then this box controls whether or not the analog data will be read from the C3D file.

Calibrate Forces

If an analog file is present, and the auto-load analog data box is checked (see above), then this box is active and gives you control over the calibration of the forceplate data. When this box is checked, SIMM determines the baseline of each forceplate channel and automatically subtracts these baseline values from the data, thus "zero-ing out" the force data.

Remove Old Forceplates

In order to display forceplate data that is in the analog file, SIMM creates graphical objects in the model window representing the forceplates. Each time you load a tracked marker file with corresponding analog data, SIMM creates a new graphical object for each forceplate in the file. In most cases you will want to remove the existing forceplate objects from the model when loading a new file, so that the display is not cluttered with multiple (or redundant) sets of objects. Thus this option is turned on by default. If you load a series of marker and analog files that all have the same forceplate definitions, then you should leave this option turned on.

Read Marker Names From

For C3D import only: This option allows you to choose from which parameter field in the C3D file to read the names of the tracked markers. Because the `POINT:LABELS` field in a C3D file is limited to four characters, some software packages (*e.g.*, EVaRT) store the full marker name in the `POINT:DESCRIPTIONS` field. Since the marker names in the tracked file must exactly match the names used in the mocap model, if your C3D file does not contain full marker names in the `POINT:DESCRIPTIONS` field, you may have to edit the mocap model so that the marker names match the four-character names stored in the `POINT:LABELS` field.

Save HTR File

This option allows you to save an HTR file containing the motion that SIMM calculates from the marker data. This HTR file cannot be read back into SIMM, but is useful if you want to import the motion into another software package. If this box is checked, a browse button is enabled that allows you to specify the name and location of the HTR file.

Save Motion File

This option allows you to save a SIMM motion file containing the motion that SIMM calculates from the marker data. This file contains exactly the same data that is in the motion that SIMM loads onto the model. You can load this motion file into SIMM at a later time, rather than re-importing the marker file. If this box is checked, a browse button is enabled that allows you to specify the name and location of the motion file.

Analog Data

Analog data files contain forceplate and EMG data that was collected in sync with motion data. When loading C3D files, there are no separate analog files; all of the analog data is contained in the C3D file. When loading TRB/TRC files, you can load analog files only if they correspond to the chosen TRB/TRC files. If the analog file has the same base name as the TRB/TRC file, then the Motion Module will load it automatically when you select the marker file. Otherwise, you should select the analog file as well in the file browser. The same holds for XLS files, which are not actually analog files, but are treated similarly. XLS files can contain other data corresponding to the recorded motion, such as kinetic data calculated by OrthoTrak and stored in a "single trial spreadsheet."

SIMM can recognize three types of analog data: ground reaction forces, EMG activation levels, and "other" data (usually kinetic data from an XLS file). These data types, and how they are interpreted by SIMM, are described below:

Forceplate Data

SIMM displays forceplate data by drawing a vector in the model window at the appropriate point of application and with a size corresponding to the magnitude of the force. Forceplate data in an analog file are voltages measured by forceplate transducers. These voltages are converted into forces using a calibration file, **forcepla.cal**. This file is the same one used by EVa, EVaRT, and OrthoTrak. To use it with SIMM, you should put a copy of it in the same folder as your motion data, or in the folder **SIMM\Resources\ mocap\misc**. If you have only one forceplate configuration for your motion capture system, it is preferable to put *forcepla.cal* in **SIMM\Resources\mocap\misc,** rather than copying it into every folder of motion data.

Note: C3D files that contain force plate data also contain the calibration information for the plates. Thus there is no separate calibration file that SIMM reads when importing C3D files.

SIMM also uses another configuration file, **importVariables.txt**, to map forceplate channels to SIMM variables. This file is located in **SIMM\Resources\mocap\misc**, and contains mappings for typical channel names for up to six forceplates. You will only need to change this file if you use more than six forceplates, or use forceplates that have exotic channel configurations. This file is used when loading ANB/ANC files and when loading C3D files.

EMG Data

SIMM displays EMG data by varying the sizes and colors of the corresponding muscles in the SIMM model. EMG data in an analog file are voltages measured by the EMG system. SIMM rectifies and smooths these data, and then scales them based on an MVC value (maximum voluntary contraction), resulting in a smooth muscle excitation level that varies between 0.0 and 1.0. If MVC values are located in the configuration file **importVariables.txt**, SIMM will use them to scale the EMG data. If MVC values are not present, SIMM will use each muscle's maximum voltage in the analog file to scale that muscle's EMG data (thus each muscle's excitation will peak at 1.0 sometime during the motion). The file **importVariables.txt,** located in **SIMM\Resources\mocap\misc**, contains mappings between typical EMG channel names and the muscle names in the mocap model. It does not contain any MVC values. In most cases, however, it is sufficient to not specify them and use SIMM's default scaling method.

Other Data

"Other" data is contained in XLS files, and can represent any motion variable that you choose to calculate and store in the file. It is usually reserved for kinetic data (*e.g.*, joint moments and powers) that OrthoTrak calculates and stores in its spreadsheet (XLS) format. It may also include motion events, such as toe-off and heelstrike, that are stored at the top of the XLS file. SIMM does not perform any calculations on these data, but does import them so that you can create plots of them in the Plot Maker. SIMM will only import "other" data that are identified as such in **importVariables.txt**. This configuration file, located in **SIMM\Resources\mocap\misc**, contains mappings between OrthoTrak and the mocap model of all forces, moments, and powers for the hip, knee, and ankle joints. You will only need to edit this file if you want to import data other than these.

Real-time Import

In addition to importing tracked marker files, SIMM can import motion data that is sent over the network in real-time from EVaRT. SIMM is thus able to animate a musculoskeletal model and plots of joint angles and muscle lengths while the subject's motion is being recorded. For this real-time connection, **EVaRT** solves tracked marker data using the mocap model. It then sends generalized coordinate values (as well as analog data) over the network to the SIMM computer. If the same mocap model is loaded into SIMM, these generalized coordinates will drive the animation of the model in real-time, with a small delay (whose length depends on the network speed and the graphics speed of the SIMM computer).

Follow these steps to use the real-time connection between EVaRT and SIMM:

First-time setup only:

1. Find the folder **SIMM\EVaRT** on your SIMM computer and look for **mocap.jnt** and **solver.dll** (**solver.dll** may be hidden in the folder view because it is a system file). Copy both files to the folder on the **EVaRT** machine (you'll need to exit **EVaRT** first, if it is running). This will guarantee that **EVaRT** is using the same mocap model and the same scaling algorithms as SIMM uses.

2. Open the text file **SIMM\Resources\preferences** in a text editor such as Notepad or Wordpad. Locate the line that reads: `EVART_MACHINE <hostname>`, and change the hostname to the name of your **EVaRT** machine. Save and close the preferences file (make sure that the file is saved as ASCII text with the name preferences—Wordpad likes to surreptitiously append a **.txt** extension when it saves files that don't already have a filename extension).
3. If your motion capture system includes forceplates, copy the file **forcepla.cal** from your **EVaRT** computer onto your SIMM computer and put it in the folder **SIMM\Resources\mocap\misc**.

Each motion capture session:

4. Copy the folder containing the motion data from the EVaRT computer to the SIMM computer (or make it shared). If there is a **personal.dat** file for this data, make sure it is in the folder too.
5. Launch **EVaRT**. Load the appropriate project.
6. Select **File > Load Tracks File** and select the tracked marker file corresponding to the static trial for the subject.
7. Under **Setup > Misc**, click on the radio button for **SIMM OrthoTrak Solver**, located in the Skeleton Options area.
8. Launch SIMM.
9. Select **File > Open Mocap Model** and navigate to the motion folder. Choose the tracked marker file containing the static pose.
10. Set the options as desired in the dialog box and click **OK**.
11. Open the Model Viewer window.
12. In the Model Viewer window, choose **Start > Realtime Connection to <hostname>**. SIMM will display a dialog box allowing you to set some options for the connection. The motion buffer size options control how many seconds of motion data are saved in SIMM's buffer. The *time scale* options let you specify the minimum and maximum values, in seconds, for the time scale of the motion. If you want the scale to remain fixed between minimum and maximum, check the sliding checkbox, otherwise the scale will continue to increase as new data is received.
13. SIMM will now wait to receive data from the **EVaRT** computer. Once the connection is established, SIMM will display "connected" in its message window, and the SIMM model will begin tracking the motion of the subject in real-time. You can pan, zoom, rotate, and change the draw mode of the SIMM model as it is tracking the motion. You can also create plots of kinematic variables and muscle properties and see the plots change in real-time.
14. To disconnect SIMM from the real-time stream, click the **Stop** button in the Model Viewer. You can play back the last N seconds of the motion.

Note: When analog data is imported into SIMM in real-time, it is processed slightly differently than when the data is post-processed in SIMM. This is because the real-time analog data is processed frame-by-frame, without the benefit of the full data set. This has the following implications:

- To set the baseline for the forceplates, the first frame of force data is used as the "zero" level. Thus when you first connect SIMM to **EVaRT**, you should make sure that nothing is on the forceplates.

- If no MVC levels have been specified for some of the muscles, a running tally of each muscle's maximum level will be kept, and used to scale the EMG signals into the range 0.0 to 1.0. Thus if you want to accurately scale EMG levels throughout a real-time SIMM motion import, you should either specify MVC levels, or have the subject perform MVCs just after connecting SIMM to EVaRT.

Using the Mocap Model

SIMM has the ability to read tracked marker data and convert it into a motion by fitting a musculoskeletal model to it. For this to work well, the body segment lengths, marker names, and marker locations in the model must exactly match those for the subject whose motion is being recorded. Because it is time consuming to measure and scale the body segments, and measure and record the offsets of all of the markers, the Motion Module has the ability to automatically scale a pre-made model (the mocap model) to fit the subject.

To use the mocap model, select **Open Mocap Model** from the **File** menu. SIMM will display a Windows® file browser and ask you to select the name of a static pose file. This static pose is used to calculate joint center locations and segment lengths for the subject, using the same algorithms implemented in OrthoTrak. In other words, *the Motion Module recreates the OrthoTrak skeletal model from the static pose, and then maps this skeletal model onto the mocap model*. Thus to use the mocap model, you need to use the same motion capture protocol as you would for OrthoTrak. You can use either the Helen Hayes or Cleveland Clinic marker sets (plus your own additional markers, if desired), as long as the marker names and locations match the protocol defined in the OrthoTrak manual. The Motion Module uses the tracked marker data from the OrthoTrak static pose, and also segment information from **personal.dat,** to scale the mocap model to the subject. The algorithms for calculating joint center locations and segment lengths have been designed to be as similar as possible to the OrthoTrak algorithms. This was done so that motion information in SIMM (*e.g.*, joint angles, EMG levels) would match the corresponding information in OrthoTrak, and also so that you would not have to change your OrthoTrak protocol in order to use SIMM.

The mocap model and the algorithms used to scale it are described in the following sections.

The Mocap Model

The mocap model is a full-body SIMM model that has been customized for gait analysis, but can be used to import and display any type of full-body motion. The model has 41 body segments, 41 joints, 40 degrees of freedom, and 88 lower-extremity muscles. It represents an adult male, approximately 175 cm. tall, with a mass of 78 kg. The model is scaled to match the size of the motion capture subject using algorithms described in Section 5.3.4. The model's joints have been carefully constructed to represent normal joint motion as closely as possible.

To load the mocap model into SIMM, the software looks for the `MOCAP_MODEL` variable in the preferences file (**SIMM\Resources\preferences**) to get the name of the joint file that comprises the mocap model. The default setting for this variable is **SIMM\Resources\**

mocap\mocap.jnt. This joint file includes the file **mocap.msl** to get the definitions of the muscles.

You may change the mocap model however you wish. For example, you can add or remove muscles from the model, or change the tendon and fiber parameters of existing muscles. You can also add degrees of freedom to the model, in order to more accurately represent a particular motion (*e.g.*, adding toe joints and gencoords to examine toe motion in greater detail). If you modify the mocap model, however, you should keep in mind two things.

First, the model has been set up to correspond to the skeletal model that OrthoTrak uses when processing gait data. The lower-extremity body segments and orientations of the reference frames closely match those in the OrthoTrak model. Also, each body segment in the mocap model is scaled to fit the subject by relating its length to the length of an OrthoTrak segment. These relations are specified in the mocap model by defining scale segments and scale factors for each body segment. If you add, delete, or modify joints or body segments in the mocap model, you should make sure that each segment still properly relates to an OrthoTrak segment.

Second, **mocap.jnt** contains several macros that are used to properly define the orientation of the floor, and to automatically remove the upper body segments if there are no upper body markers. When SIMM reads a joint file, it performs these macros but does not save them internally. Thus when it writes out a joint file, all of the macros have been removed. If you make changes to the mocap model in SIMM and then save the new model to a file, do not replace *mocap.jnt* with the new file. Instead, copy the relevant portions of the new file into *mocap.jnt* using a text editor, thus preserving the macros and comments.

The Static Pose

When you open the mocap model, SIMM prompts you for the name of a tracked marker file containing a static pose of the subject. This static pose is the same one used by OrthoTrak, and for it you can use any of the six marker sets identified by that software package: *Cleveland Clinic Lower Body*, *Cleveland Clinic Full Body*, *Cleveland Clinic Full Body with Head*, *Helen Hayes Lower Body*, *Helen Hayes Full Body*, and *Helen Hayes Full Body with Head*. It is also strongly recommended that you include the medial knee and ankle markers in the static pose, for more accurate calculation of knee and ankle joint centers. You can also supplement the OrthoTrak marker set with your own custom markers, as long as you do not move or remove any markers from the identified set. Lastly, the marker set used in the static trial must include all of the markers you plan to use for capturing motion. This is because the Motion Module calculates the locations of all markers in the mocap model based on their locations in the static trial. These are the steps you should follow when collecting the static trial:

1. Choose which of the six OrthoTrak marker sets you would like to use for capturing motion.
2. Add the medial knee and ankle markers, for better calculation of knee and ankle centers (not required, but highly recommended).
3. Add any additional markers that you would like to use (*e.g.*, extra markers on the feet, more markers on the arms). These markers must also be added to the mocap model, The Marker Set.

4. Capture the static trial using the protocol outlined in the OrthoTrak manual. The subject should have their arms either down by their sides, or straight out from their body with their thumbs facing forward.
5. Remove the medial knee and ankle markers, and any others that you do not want to use for capturing motion.

Note: If you use a marker set with no upper extremity markers, the Motion Module will remove the upper extremity from the mocap model and display only the pelvis and legs.

Once you have selected the static pose file to be used for opening the mocap model, SIMM displays a dialog box, allowing you to set some options for importing the static pose. In many cases, you will want to use the default settings for these options, so you can simply click the *OK* button to import the motion. The following list describes each option in the dialog box:

average from frame

These fields allow you to specify the starting and ending numbers for the sequence of frames that are averaged together to determine the static pose. These fields are initialized to 1 and the number of frames in the file, meaning that all frames will be averaged. If frames in the chosen sequence are missing some markers, locations for markers that are present will still be used in the average.

load personal.dat

This option gives you control over the automatic loading of **personal.dat.** When SIMM loads the static marker file, it looks for a file called **personal.dat** in the same folder. This file is identical to the one created and used by OrthoTrak. If the file is present, SIMM will automatically load it and read model parameters from it, such as foot length and hip origin offsets. It will use these parameters to determine joint center locations and segment lengths, using the same algorithms that OrthoTrak does. If there is no **personal.dat** file present in the folder, this option will be grayed out. If it is checked and you do not want to load **personal.dat**, click the box to turn it off.

read marker names from

For C3D import only: This option allows you to choose from which parameter field in the C3D file to read the names of the tracked markers. Because the `POINT:LABELS` field in a C3D file is limited to four characters, some software packages (*e.g.*, **EVaRT**) store the full marker name in the `POINT:DESCRIPTIONS` field. Since the marker names in the tracked file must exactly match the names used in the mocap model, if your C3D file does not contain full marker names in the `POINT:DESCRIPTIONS` field, you may have to edit the mocap model so that the marker names match the four-character names stored in the `POINT:LABELS` field.

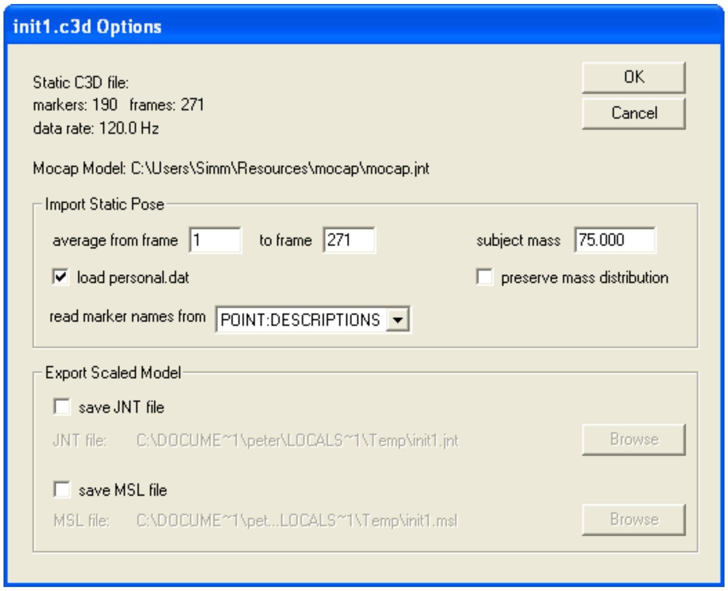
subject mass

This field allows you to specify the total mass of the model after it has been scaled to fit the size of the subject. After the scaling is done, all the body segments' mass parameters are scaled up or down by a single percentage so that the total mass of the model equals the number entered into this field. This field has no effect if mass properties are not specified in the model file.

preserve mass distribution

This option gives you control over how the mass properties of the individual body segments are scaled. If this option is off, then each body segment's mass is scaled proportionally with its size. If this option is on, then each segment's mass parameters are not scaled with their change in size (i.e., the distribution of body mass specified in the model file is preserved). In either case, after the model has been scaled, all the body segments' mass parameters are scaled up or down by a single percentage so that the total mass of the model equals the number entered into the "subject mass" field.

Figure H-3. Static Trial Import Dialog Box



Static C3D file:
markers: 190 frames: 271
data rate: 120.0 Hz

Mocap Model: C:\Users\Simm\Resources\mocap\mocap.jnt

Import Static Pose

average from frame 1 to frame 271 subject mass 75.000

☑ load personal.dat ☐ preserve mass distribution

read marker names from POINT:DESCRIPTIONS

Export Scaled Model

☐ save JNT file
JNT file: C:\DOCUME~1\peter\LOCALS~1\Temp\init1.jnt

☐ save MSL file
MSL file: C:\DOCUME~1\pet...LOCALS~1\Temp\init1.msl

Save JNT File, Save MSL File

These options allows you to specify if SIMM will write out joint and muscle files containing the musculoskeletal model that is scaled to fit the subject. After SIMM has loaded the mocap model and scaled it based on the data in the static marker file and **personal.dat**, it will write out corresponding joint and muscle files, depending on the states of these check boxes. You may want to create these files so that you can make changes to them or to be able to re-load the model without going through the scaling process again.

Calculation of Joint Centers

Once the static pose has been loaded, the Motion Module recreates the OrthoTrak skeletal model from the marker cloud. The first step is determining the locations of the joint centers for all of the joints in the OrthoTrak model. The pelvis, hip, knee, and ankle centers are all found using the same procedure used by OrthoTrak.

The hip center is determined using percentage offsets from the pelvis markers. The Motion Module reads these offsets from **personal.dat**, as written by OrthoTrak. The default values for these offsets are taken from *Bell et al. Journal of Biomechanics, 23(6), 1990, pp. 617-21*:

posterior displacement: 22%
lateral displacement: 32%
inferior displacement: 34%

To change these values, edit the file **personal.dat,** as described in Appendix D of the OrthoTrak manual.

The knee and ankle centers are found using the medial and lateral markers. It is strongly recommended that you use medial markers for a more accurate calculation of joint centers. If you choose not to use them, you should enter knee and ankle diameter measurements into **personal.dat**. The Motion Module will use them to locate the knee and ankle centers if no medial markers are used.

The default method for determining shoulder, elbow, and wrist joint centers uses percentage offsets from the appropriate marker locations. If medial elbow and wrist markers are used in the static trial, their locations are averaged to get the joint centers, as is done with the knee and ankle. It is recommended that you use medial elbow and wrist markers in the static trial if you want an accurate representation of arm motion.

Scaling the Mocap Model

Once the locations of the OrthoTrak joint centers have been calculated from the static pose, the Motion Module determines the orientations of the OrthoTrak segment reference frames. It then can measure the lengths of the OrthoTrak segments and use them to scale the mocap model to match the size of the subject.

The reference frames for the foot, shank, thigh, pelvis, and torso are all determined using the procedure described in Appendix H of the OrthoTrak manual.

OrthoTrak does not create reference frames for the upper and lower arms, but the Motion Module does this using one of several methods. If medial elbow and wrist markers are used in the static trial, then the arm reference frames are found in the same way in which the thigh frames are found. If no medial markers are present, then the upper and lower arm reference frames are found using the line between the joint centers as the X axis, and using the same Y axis as the torso. The Z axis is then determined by crossing X and Y.

Once all of the segment reference frames have been determined, the length of each segment is calculated. For most segments, the length is simply the distance from one joint center to the next. For the foot, the Motion Module reads the length from **personal.dat.** If there are no foot length measurements in **personal.dat**, then the foot length is assumed to be 1.4 times the distance from the heel marker to the toe marker (the toe marker is actually placed on the top of the foot just posterior to the toes).

Each body segment in the mocap model contains scaling information that tells the Motion Module how to scale it based on an OrthoTrak skeletal segment. The scaling information consists of the name of the OrthoTrak segment and X, Y, and Z reference numbers that correspond to the unscaled length of the SIMM segment. For example, the right femur in the mocap model contains the line:

gait_scale R_THIGH 0.3960 0.3960 0.3960

This tells the Motion Module that the unscaled femur is 0.3960 meters long. Once the length of the corresponding OrthoTrak segment is known (R_THIGH), the femur can be scaled accordingly. If the R_THIGH segment were 0.35 meters long, then the femur would be scaled by a factor of 0.35/0.396. In most cases the three reference values are the same number, indicating that the segment should be scaled uniformly in X, Y, and Z. The two exceptions are the TORSO and PELVIS, which are scaled differently in two dimensions. For SIMM segments that do not map directly to an OrthoTrak segment, their scaling information is copied from the most relevant segment. For example, the right hand in the mocap model copies the scaling information from the right lower arm, so that the hand is scaled the same amount as the lower arm.

The Marker Set

The marker set in the mocap model that comes with SIMM includes every marker used in all six marker sets that OrthoTrak recognizes, plus the medial knee and ankle markers. In addition, many other markers have been added, such as medial elbow and wrist markers. For a complete list of the markers in the model, as well as information on when they should be used and where they should be placed on the subject, read the *Guide to Mocap Model Markers* document. The mocap model contains over 80 markers, which is more than the number used in most applications. When the static trial is loaded, any marker in the mocap model which is not in the static trial is removed from the model. Thus it is not a problem to have extra markers in the mocap model. In fact, you should add to the model whatever extra markers you may need for any of your motion capture applications. Then for a particular application the mocap model will have all the necessary markers, and the unused ones will automatically be removed when the model is loaded into SIMM.

To add or change markers in the mocap model, use the Marker Editor. You should be careful not to overwrite the original **mocap.jnt** file. Instead, after editing the marker set, save the model to a new file name, and copy the altered markers into **mocap.jnt**.

All of the markers in the mocap model have X, Y, and Z offsets that put them in realistic locations given the dimensions of the generic model. Thus if you load the unscaled mocap model into SIMM (using the **File > Open** command, not the **File > Open Mocap Model** command, which will scale it), the markers will appear in positions corresponding to where they are placed on the subject. *These offsets are purely decorative, to help you view the marker set. They are not used by the Motion Mod-*

ule to process any marker data. To explain why this is so, we must first introduce the concept of *critical* markers and *non-critical* markers.

Critical markers are ones that must be present in the static trial in order for the Motion Module to load and scale the mocap model. For the lower body, these markers are: V.Sacral, R.ASIS, L.ASIS, R.Knee (or R.Knee.Lateral), R.Ankle (or R.Ankle.Lateral), R.Heel, R.Toe, L.Knee (or L.Knee.Lateral), L.Ankle (or L.Ankle.Lateral), L.Heel, and L.Toe. If any of these markers is missing from the static trial, the SIMM model of the lower body will not be loaded. For the upper body, the critical markers are: V.Sacral, R.ASIS, L.ASIS, R.Shoulder, R.Elbow, R.Wrist, L.Shoulder, L.Elbow, L.Wrist. Note that the ASIS and sacral markers are critical for both portions of the body. If one of these markers is missing from the static trial, you will get an error when trying to load the mocap model. Non-critical markers are all other markers in the set.

Once the Motion Module has determined the locations of the joint centers and the orientations of the segment reference frames from the static pose, it calculates the proper offsets for all of the critical markers (plus the static-only medial markers). For example, once the right thigh reference frame has been oriented within the static pose marker cloud, the exact positions of the critical markers attached to the right thigh can be measured directly from the static pose and entered into the mocap model, thus overwriting whatever offsets were in the model input file.

After the offsets of all the critical markers have been determined in this fashion, the mocap model is “fit” to the static pose marker cloud using only the critical markers to find the best fit. This process orients the mocap model within the marker cloud, so that the offsets of the non-critical markers can be measured directly from the static pose. These offsets are then entered into the model, overwriting whatever values were in the model input file.

To summarize, the Motion Module uses a two-step process to calculate proper offsets for all of the markers in the mocap model. The first step determines the offsets of the critical markers, which the OrthoTrak algorithms can definitively locate without knowing anything about the mocap model. Then these critical markers are placed on the mocap model, and the model is fit to the static pose marker cloud. Now the offsets of the other markers can be measured, because every body segment in the mocap model is now correctly placed in the static pose.

Analog Configuration Files

SIMM can include analog data such as ground reaction forces, EMG activation levels, and kinetic data when importing a motion. SIMM uses a configuration file named **importVariables.txt** to determine which analog variables to import from an analog file, and how the data for each variable should be interpreted. This configuration file is used for both TRB/TRC import (with corresponding ANB/ANC analog files) and for C3D import (where the analog data is contained in the C3D file itself). SIMM can interpret analog data as one of three types:

Forceplate Data

These variables specify voltages representing force or moment components as measured by a forceplate transducer. Given the voltages generated by a forceplate (6 channels for an AMTI or Bertec forceplate, 8 channels for a Kistler forceplate) SIMM can calculate and display a force location and vector for the forceplate.

EMG Data

These variables define activation levels for one or more muscles in the SIMM full-body model. SIMM rectifies, smooths, and scales EMG data so that it can be plotted, and used to control the width and color of muscles during an animation.

Other Data

Any variables that are not forceplate or EMG data are classified as other data. SIMM does not perform any calculations on these data variables, but they may be included in SIMM plots.

importVariables.txt

The **importVariables.txt** file, located in **SIMM\Resources\ mocap\misc**, contains a list of variable names and attributes. When SIMM processes an analog data file or an OrthoTrak XLS file, it consults the **importVariables.txt** file to decide which variables to import and how to interpret them.

Each row in **importVariables.txt** defines a variable to be imported. The first column in a row specifies the name of the variable as it appears in the analog or XLS data file. Since certain analog files support variable names with spaces in them, the first column of the **importVariables.txt** file *must* be terminated by a tab character. SIMM considers all characters from the beginning of a row until the first tab character to be the name of the import variable. SIMM does a case-insensitive comparison when matching variable names defined in **importVariables.txt** with variable names in an analog data file. Therefore the name "Rt Tibialis" would be considered the same as "rt tibialis".

The second column in a variable definition specifies the type of the variable. It must be one of the following keywords: `force_plate`, `muscles`, or `other_data`. These keywords must be lowercase. Following each keyword is information describing the variable:

This keyword specifies a ground reaction force variable. It must be followed by three values:

1. The forceplate number (`1`, `2`, `3`, etc.), then
2. The keywords `force` or `moment`, then

3. The channel component (`x`, `y`, or `z` for AMTI or Bertec forceplates, or `x12`, `x34`, `y14`, `y23`, `z1`, `z2`, `z3`, `z4` for Kistler forceplates).

This keyword specifies an EMG variable. It must be followed by one or more SIMM muscle names. The keyword `mvc` may optionally appear after the last muscle name. If `mvc` appears, then it must be followed by an integer number that SIMM uses as the voltage for the maximum voluntary contraction when scaling that EMG channel. If no MVC value is specified, then the channel is scaled such that its maximum value is 1.0. EMG scaling is performed after the EMG channel's data has been smoothed and resampled to the motion's frequency.

This keyword specifies a data channel that exists simply to be included in SIMM plots. This keyword may be optionally followed by a single word that will be used to label this channel in SIMM plots. If no name follows the `other_data` keyword, then the name of the imported variable will be used.

forcepla.cal

When importing analog data from ANB/ANC files, SIMM uses the same calibration file as EVaRT and OrthoTrak for processing forceplate data. Therefore, you can simply copy the **forcepla.cal** file from your EVaRT folder into the **Resources\mocap\misc** folder. For users who need to create a **forcepla.cal** file to describe their forceplate(s), refer to Appendix C of the OrthoTrak manual.

Note: **forcepla.cal** is not used for C3D import since C3D files contain the necessary calibration information for the force plates.

SIMM Motion Module Guide to Mocap Model Markers

This guide describes the markers used by the Motion Module in SIMM to load each Mocap Model, scale it to fit the subject, and import recorded motions. For details on how the Motion Module processes the marker data and the model, see Chapter 5 of the SIMM User Guide. For a tutorial of the Motion Module, click on Help-> SIMM Tutorials -> Motion Module Demo in the SIMM menu bar. This document focuses on the names and locations of the markers, and when they are needed by the Motion Module.

Definitions

Static Trial

A TRC, TRB, or C3D file of a motion capture subject in a static pose, usually the “T” or “scarecrow” pose

Motion Trial

A TRC, TRB, or C3D file of a subject performing an activity, such as walking or throwing

Mocap Model

A SIMM musculoskeletal model that can be loaded into SIMM, scaled to fit a subject using a static trial, and used to animate motion trials of that subject. The primary model is a full-body model with lower-extremity muscles, but others are available as well.

Critical Marker

A marker that is required in the static trial, and which must be placed in a specific location on the subject, according to instructions in the OrthoTrak manual. The coordinates of the marker in the static trial are used to determine joint centers and body segment lengths.

Semi-critical Marker

A marker that is optional in the static trial, but if used, must be placed in a specific location on the subject, according to instructions in the OrthoTrak manual. The coordinates of the marker in the static trial are used to improve the joint center calculations.

Optional Marker

A marker that is optional in the static trial, and whose placement on the subject does not need to be in a specific location

Fixed Marker

An optional marker whose X, Y, Z offsets are not automatically calculated when the static trial is processed. Rather, the offsets in the marker definition in the Mocap Model file are used to position the marker on the model (these offsets are scaled with the body segment, however).

The Motion Module comes with four different Mocap Models for you to choose from. Each of them contains parameters that turn on and off different portions of the model, depending on which of the critical markers are present in the static trial. When you load a Model Model with a static trial, the Motion Module reads the list of markers from the trial and sets the values of the model parameters so that the appropriate portions are included. For example, if the critical markers on the right hand are present, then the degrees of freedom in the fingers are activated. If they are not present, the hand is modeled as one rigid body segment, with movement only at the wrist.

The Mocap Model that you will most likely want to use is **mocap.jnt**. This is a model of a full body, with lower extremity muscles and [optionally] movable fingers in each hand. There is also a right arm model and a left arm model (**rightArm.jnt** and **leftArm.jnt**). These should be used if you want to capture motion of one arm without any torso or pelvis markers. Lastly, **mocap3D.jnt** is similar to **mocap.jnt**, but it includes 3D muscle surfaces for 18 key lower extremity muscles, rather than the lines of action for all 86 muscles. These muscle shapes look more realistic, but they do not have force-generating parameters, so you cannot calculate the lengths or forces in these muscles during the recorded motion.

Table H-1 on page H-19 shows the available combinations of model components. To determine which Mocap Model you should use, find the row that best describes the model you want, then locate the filename in the last column. All of these files are located in **SIMM\Resources\mocap**. Once you have determined which one to use, you can either set the MOCAP_MODEL variable in **SIMM\Resources\preferences** to that file, or choose that file using the **Options...Choose Model Model** command in the SIMM menu bar.

Table H-1. Combinations for Model Components

lower extremity	upper extremity	movable fingers	muscles	file name
yes	yes	yes	legs only	mocap.jnt
yes	yes	no	legs only	mocap.jnt
yes	no	no	legs only	mocap.jnt
no	yes	yes	none	mocap.jnt
no	yes	no	none	mocap.jnt
no	right arm only	yes	none	rightArm.jnt
no	right arm only	no	none	rightArm.jnt
no	left arm only	yes	none	leftArm.jnt
no	left arm only	no	none	leftArm.jnt
yes	yes	yes	legs only, 3D	mocap3D.jnt
yes	yes	no	legs only, 3D	mocap3D.jnt
yes	no	no	legs only, 3D	mocap3D.jnt

It is important to note that *the critical and semi-critical labels for markers are relevant only for the static trial. For motion trials, all markers are optional*. That is, after recording the static trial, you can remove any of the markers from the subject before recording motion trials. Generally, however, you will want to keep all of the markers on the subject for the motion trials, with the possible exception of the medial joint markers. Also, once the static trial has been recorded, you must be careful not to move any of the markers on the subject (except for removing them completely). SIMM uses the static trial to calculate the coordinates of each marker relative to its body segment, so if you move a marker or add additional markers, you must re-record the static trial and re-load the Mocap Model.

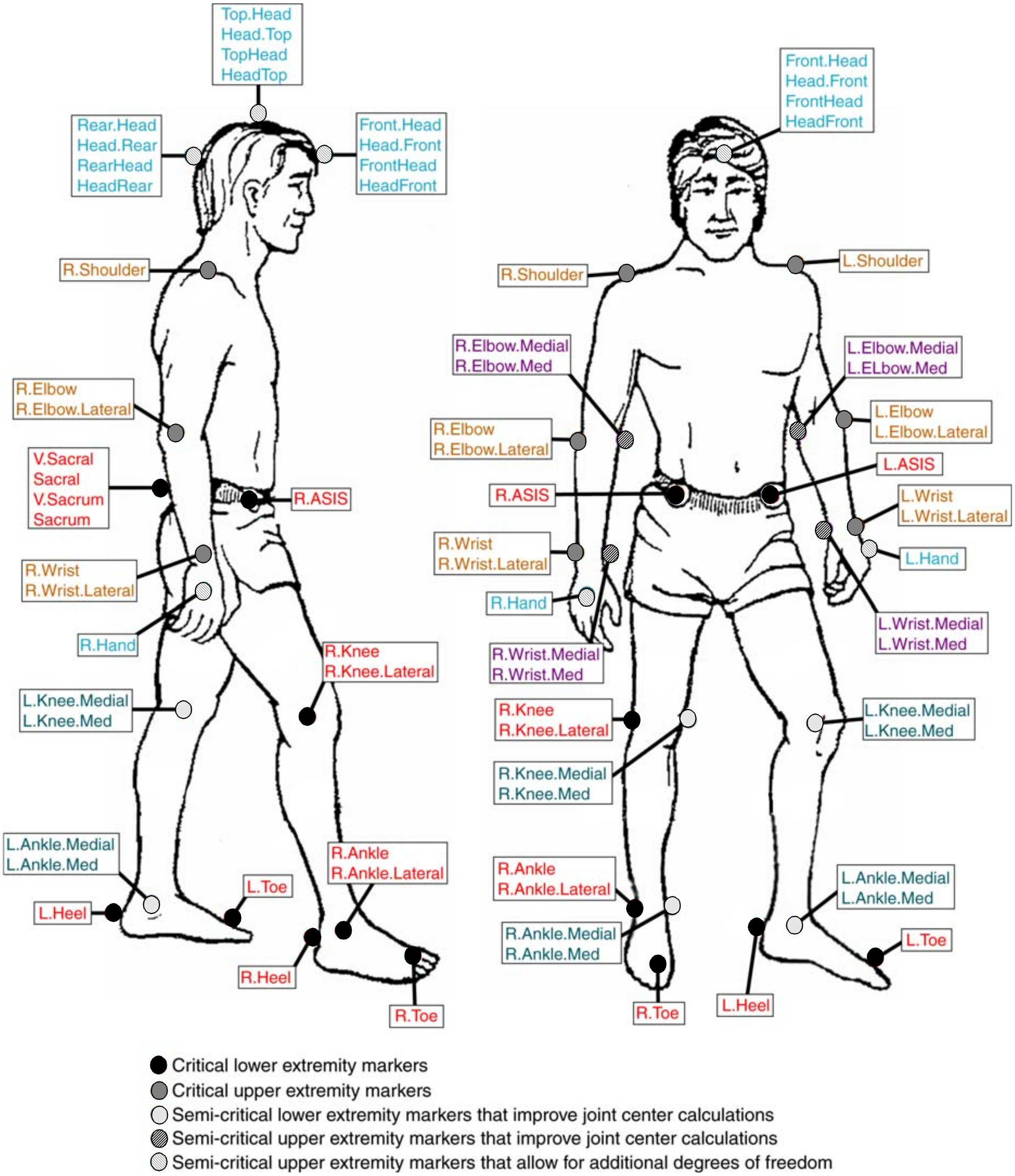
All of the markers described in this document are already part of the primary Mocap Model, located in *SIMM\Resources\mocap\mocap.jnt*. To use any of them, you do not need to make any changes to the file; just place the markers on the appropriate locations on the subject, and make sure the marker names in the static trial match the names shown in the figures below. Many of the markers can have one of several names, as listed in the box pointing to each marker in the figures. These names are case-insensitive, and may contain spaces.

If you want to add markers to the Mocap Model, you can do so with the Marker Editor in SIMM. This tool allows you to create new markers, attach them to the appropriate body segments, and specify their X,Y, Z offsets. The exact values of the offsets are not important; they are used only for display of the marker while creating it. The offsets will be overwritten with values calculated by the Motion Module when the static trial is processed and the model is scaled to fit the subject. This process is described in more detail in Chapter 5 of the SIMM User Guide, but here is a brief summary. After loading the static trial, the Motion Module places all of the critical markers that are in the trial on the Mocap Model in their corresponding locations. The Mocap Model is then scaled to match the subject, and then a least-squares optimization fits the model within the cloud of static trial markers, considering only the critical markers. This positions the model within the marker cloud so that the Motion Module can then directly calculate the offsets from the optional markers to the model segments to which they are attached. If you do not want the offsets for a marker to be calculated in this manner, then you must turn on the "fixed" button for that marker in the Marker Editor, and enter accurate X, Y, Z offsets into the number fields. This tells the Motion Module to scale the marker's offsets when the model is scaled, but not to recalculate their values as it does for the other optional markers.

Note on adding markers: You can create new markers using the Marker Editor, and then save the model by writing out a joint file, but you should not replace the original model file (*e.g.*, **SIMM\Resources\mocap\mocap.jnt**) with this new file. This is because the model file contains many comments and special parameters that enable SIMM to automatically modify it for a particular static trial, as described above. However, when this file is loaded into SIMM and then written back out, these comments and parameters are lost. Thus after saving your new joint file, you should use a text editor to copy the new marker definitions from the file and paste them into the existing model file.

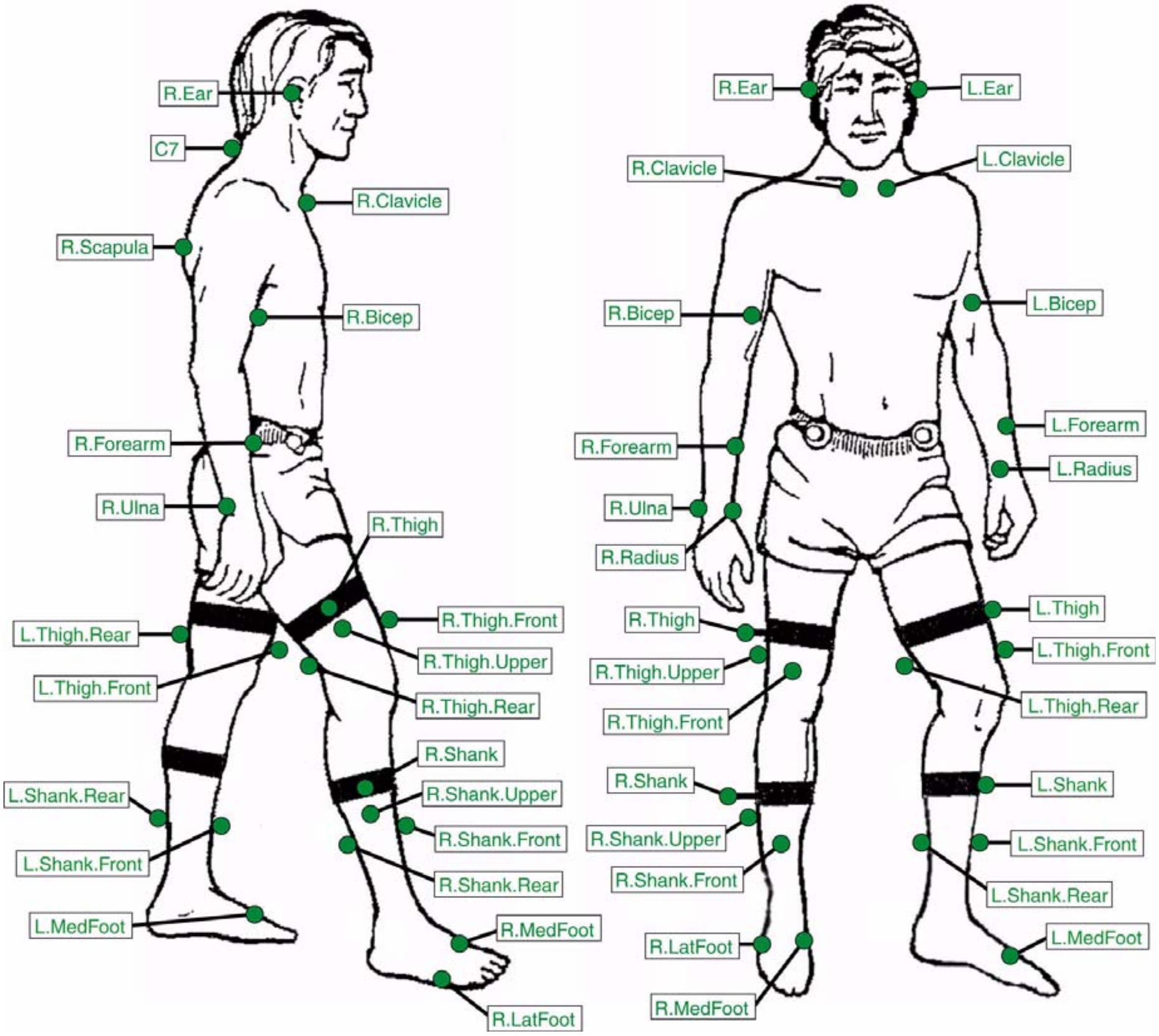
Shown in Figure H-4 on page H-21 are the critical and semi-critical markers for upper body and lower body motion recording. If any of the lower body critical markers is missing from the static trial, the legs will not be loaded with the Mocap Model. Similarly, if any of the upper body critical markers is missing from the static trial, the torso, head, and arms will not be loaded. Note that the sacral, left ASIS, and right ASIS markers are critical for both upper and lower body motion recording. If any of these markers is missing, the Motion Module will print an error and not load the Mocap Model. The head and hand markers are semi-critical. If used, they allow the Motion Module to track motion at the neck and wrist. If not used, these joints will remain fixed during animation of motion trials in SIMM.

Figure H-4. Critical and Semi-Critical Markers


Top.Head
Head.Top
TopHead
HeadTop
Rear.Head
Head.Rear
RearHead
HeadRear
Front.Head
Head.Front
FrontHead
HeadFront
R.Shoulder
R.Elbow
R.Elbow.Lateral
V.Sacral
Sacral
V.Sacrum
Sacrum
R.ASIS
R.Wrist
R.Wrist.Lateral
R.Hand
R.Knee
R.Knee.Lateral
L.Knee.Medial
L.Knee.Med
L.Ankle.Medial
L.Ankle.Med
R.Ankle
R.Ankle.Lateral
L.Toe
L.Heel
R.Heel
R.Toe
Front.Head
Head.Front
FrontHead
HeadFront
R.Shoulder
L.Shoulder
R.Elbow.Medial
R.Elbow.Med
L.Elbow.Medial
L.ELbow.Med
R.Elbow
R.Elbow.Lateral
L.Elbow
L.Elbow.Lateral
L.ASIS
R.ASIS
L.Wrist
L.Wrist.Lateral
R.Wrist
R.Wrist.Lateral
L.Hand
R.Hand
L.Wrist.Medial
L.Wrist.Med
R.Wrist.Medial
R.Wrist.Med
R.Knee
R.Knee.Lateral
L.Knee.Medial
L.Knee.Med
R.Knee.Medial
R.Knee.Med
R.Ankle
R.Ankle.Lateral
L.Ankle.Medial
L.Ankle.Med
R.Ankle.Medial
R.Ankle.Med
L.Toe
R.Toe
L.Heel
● Critical lower extremity markers
● Critical upper extremity markers
○ Semi-critical lower extremity markers that improve joint center calculations
▨ Semi-critical upper extremity markers that improve joint center calculations
○ Semi-critical upper extremity markers that allow for additional degrees of freedom

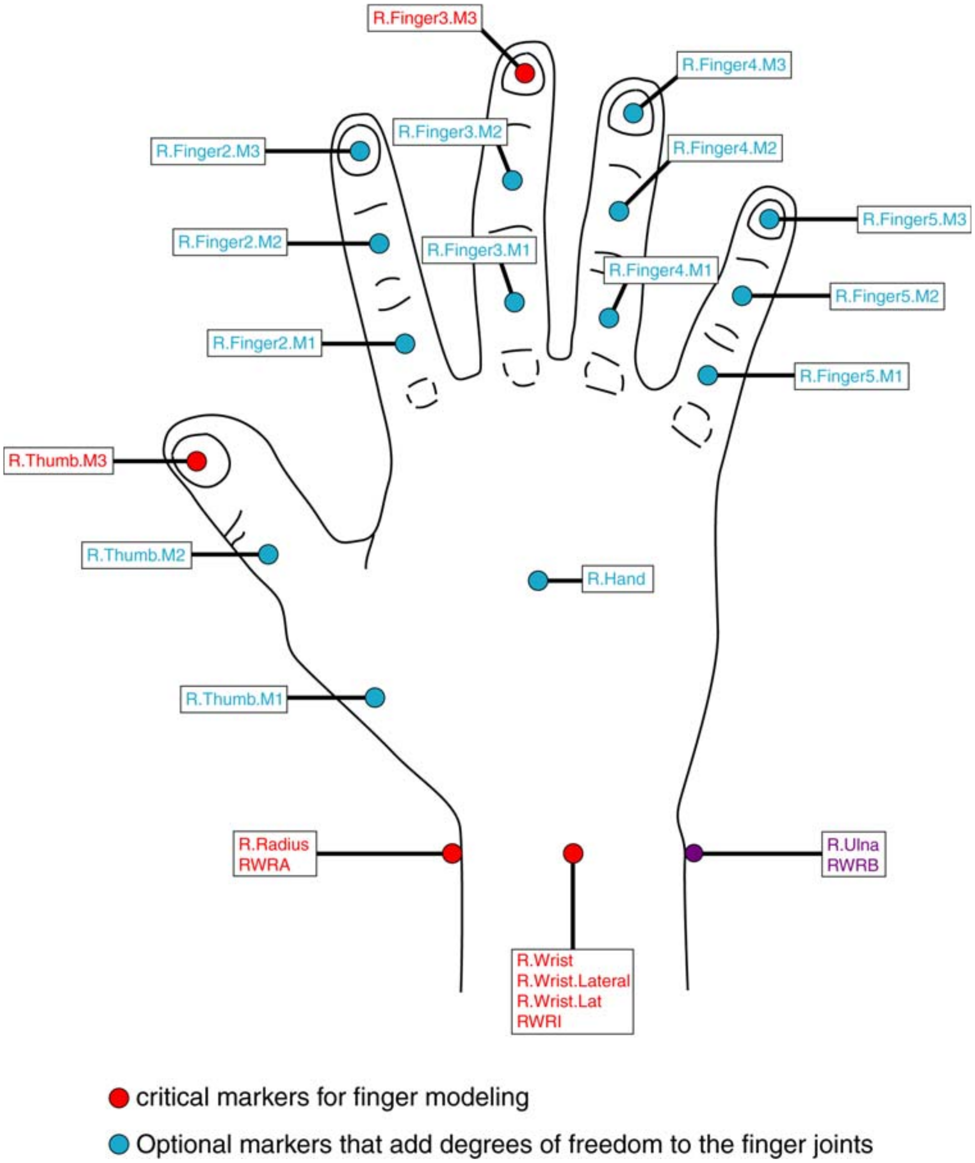
The markers shown in Figure H-5 are optional. If any of these markers is in the static trial, its location on the corresponding body segment in the Mocap Model will automatically be determined after the model has been scaled using the critical markers (*i.e.*, these optional markers are not “fixed,” so their X, Y, Z offsets in the model file will be overwritten when the model is loaded). These markers will then be used to help solve the frames of data in a motion trial.

Figure H-5. Optional Markers


R.Ear
C7
R.Clavicle
R.Scapula
R.Bicep
R.Forearm
R.Ulna
R.Thigh
L.Thigh.Rear
R.Thigh.Front
L.Thigh.Front
R.Thigh.Upper
R.Thigh.Rear
R.Shank
L.Shank.Rear
R.Shank.Upper
L.Shank.Front
R.Shank.Front
R.Shank.Rear
L.MedFoot
R.MedFoot
R.LatFoot
R.Ear
L.Ear
R.Clavicle
L.Clavicle
R.Bicep
L.Bicep
R.Forearm
L.Forearm
L.Radius
R.Ulna
R.Radius
R.Thigh
L.Thigh
L.Thigh.Front
R.Thigh.Upper
L.Thigh.Rear
R.Thigh.Front
R.Shank
L.Shank
R.Shank.Upper
L.Shank.Front
R.Shank.Front
L.Shank.Rear
L.MedFoot
R.LatFoot
R.MedFoot

The markers shown in Figure H-6 on page H-24 are used by the Motion Module to control the degrees of freedom in the hand. If the three critical markers are present in the static trial, the Motion Module will load a detailed model of the hand with three joints in each finger. By default, all of the finger joints are fixed. SIMM converts them into hinge joints as it detects the presence of markers to control the joints. For example, if R.Finger2.M1, R.Finger2.M2, and R.Finger2.M3 are all present, SIMM will create three hinge joints in the index finger, each with its own degree of freedom. If only R.Finger2.M1 is present, SIMM will create the proximal finger joint with a degree of freedom, and make the two distal joints dependent on the proximal one (so that all three joints will flex when the proximal one does). Any combination of the optional markers can be used to create a hand model with the desired degrees of freedom. All of the optional hand markers are defined as “fixed” in the model file. This means that the offsets specified in the file are used for solving motions (the Motion Module does not overwrite them), and thus you should place the markers on the subject according to how they are shown in the figure below.

Figure H-6. Critical and Optional Markers for Hands


R.Finger3.M3
R.Finger4.M3
R.Finger3.M2
R.Finger2.M3
R.Finger4.M2
R.Finger5.M3
R.Finger2.M2
R.Finger3.M1
R.Finger4.M1
R.Finger5.M2
R.Finger2.M1
R.Finger5.M1
R.Thumb.M3
R.Thumb.M2
R.Hand
R.Thumb.M1
R.Radius
RWRA
R.Ulna
RWRB
R.Wrist
R.Wrist.Lateral
R.Wrist.Lat
RWRI
● critical markers for finger modeling
● Optional markers that add degrees of freedom to the finger joints

Starting with SIMM 4.0, support has been added for alternative critical marker sets for use with the Mocap Model. For example, the sacral marker can be replaced with two PSIS markers, and the lateral wrist marker can be replaced with the radius marker. It is thus difficult to display in a single picture of the body the complete set of markers that are required. On the following pages are descriptions of the critical and semi-critical marker sets for each portion of the body. Also, for each marker, the complete list of acceptable names is shown. Any one of these *case-insensitive* names in the list can be used to identify the marker in the **EVaRT** project.

Lower Body

The lower body portion of the Mocap Model will be loaded if the critical markers listed below are present in the static trial. The thigh, shank, and feet segments will each be scaled separately, based on measurements made from the static trial. Each of these segments will be scaled uniformly in the X, Y, and Z dimensions. The pelvis segment will be scaled independently in the X, Y, and Z dimensions. It is not possible to load only one leg of the Mocap Model.

Critical Markers

1. **Right ASIS.** acceptable names: R.ASIS RASIS RASI
2. **Left ASIS.** acceptable names: L.ASIS LASIS LASI
3. **Posterior pelvis:**

   a. Sacrum. acceptable names: V.SACRAL V.SACRUM SACRAL SACRUM SACR VSAC

   or

   b. Right PSIS. acceptable names: R.PSIS RPSIS RPSI

   and

   Left PSIS. acceptable names: L.PSIS LPSIS LPSI

4. **Right lateral knee**. acceptable names: R.KNEE R.KNEE.LATERAL R.KNEE.LAT RKNE
5. **Left lateral knee**. acceptable names: L.KNEE L.KNEE.LATERAL L.KNEE.LAT LKNE
6. **Right lateral ankle.** acceptable names: R.ANKLE R.ANKLE.LATERAL R.ANKLE.LAT RANK
7. **Left lateral ankle**. acceptable names: L.ANKLE L.ANKLE.LATERAL L.ANKLE.LAT LANK
8. **Right heel.** acceptable names: R.HEEL RHEE
9. **Left heel.** acceptable names: L.HEEL LHEE
10. **Right toe.** acceptable names: R.TOE RTOE
11. **Left toe**. acceptable names: L.TOE LTOE

Semi-critical Markers

1. **Right medial knee.** acceptable names: R.KNEE.MEDIAL R.KNEE.MED
2. **Left medial knee.** acceptable names: L.KNEE.MEDIAL L.KNEE.MED
3. **Right medial ankle.** acceptable names: R.ANKLE.MEDIAL R.ANKLE.MED
4. **Left medial ankle.** acceptable names: L.ANKLE.MEDIAL L.ANKLE.MED

Upper Body

The upper body portion of the Mocap Model will be loaded if the critical markers listed below are present in the static trial. The upper arm and lower arm segments will each be scaled separately, based on measurements made from the static trial. Each of these segments will be scaled uniformly in the X, Y, and Z dimensions. The torso segment will be scaled independently in two dimensions (the X is scaled the same as the Z). It is not possible to load the upper body with only one arm. To load only one arm (without the rest of the upper body), use the SIMM file rightArm.jnt or leftArm.jnt as the Mocap Model.

Critical Markers

1. **Right ASIS.** acceptable names: R.ASIS RASIS RASI
2. **Left ASIS.** acceptable names: L.ASIS LASIS LASI
3. **Posterior pelvis:**

   a. Sacrum. acceptable names: V.SACRAL V.SACRUM SACRAL SACRUM SACR VSAC

   or

   Right PSIS. acceptable names: R.PSIS RPSIS RPSI

   and

   Left PSIS. acceptable names: L.PSIS LPSIS LPSI
4. **Right shoulder**. acceptable names: R.SHOULDER RSHO
5. **Left shoulder**. acceptable names: L.SHOULDER LSHO
6. **Right lateral elbow**. acceptable names: R.ELBOW R.ELBOW.LATERAL R.ELBOW.LAT RELB
7. **Left lateral elbow.** acceptable names: L.ELBOW L.ELBOW.LATERAL L.ELBOW.LAT LELB
8. **Right wrist**:

   a. Lateral. acceptable names: R.WRIST R.WRIST.LATERAL R.WRIST.LAT RWRI

   or

   b. Radius. acceptable names: R.RADIUS RWRA
9. **Left wrist**:

   a. Lateral. acceptable names: L.WRIST L.WRIST.LATERAL L.WRIST.LAT LWRI

   or

   b. radius. acceptable names: L.RADIUS LWRA

Semi-critical Markers

1. **Right medial elbow.** acceptable names: R.ELBOW.MEDIAL R.ELBOW.MED
2. **Left medial elbow**. acceptable names: L.ELBOW.MEDIAL L.ELBOW.MED
3. **Right wrist**:

   a. Medial. acceptable names: R.WRIST.MEDIAL R.WRIST.MED or

b. ulna. acceptable names: R.ULNA RWRB

4. **Left wrist**:

   a. medial. acceptable names: L.WRIST.MEDIAL L.WRIST.MED

   or

   b. ulna. acceptable names: L.ULNA LWRB

Right Arm

To load only the right arm, set the MOCAP_MODEL parameter in your SIMM preferences file to *rightArm.jnt*, or choose that file using the *O***ptions…Choose Model Model** command in the SIMM menu bar. Then use the markers listed below.

Critical Markers

1. **Right shoulder.** acceptable names: R.SHOULDER RSHO
2. **Right lateral elbow.** acceptable names: R.ELBOW R.ELBOW.LATERAL R.ELBOW.LAT RELB
3. **Right wrist:**

   a. Lateral. acceptable names: R.WRIST R.WRIST.LATERAL R.WRIST.LAT RWRI

   or

   b. Radius. acceptable names: R.RADIUS RWRA

Semi-critical Markers

1. **Right medial elbow**. acceptable names: R.ELBOW.MEDIAL R.ELBOW.MED
2. **Right wrist**:

   a. Medial. acceptable names: R.WRIST.MEDIAL R.WRIST.MED

   or

   b. Ulna. acceptable names: R.ULNA RWRB

Left Arm

To load only the left arm, set the MOCAP_MODEL parameter in your SIMM preferences file to *leftArm.jnt*, or choose that file using the *Options…Choose Model Model* command in the SIMM menu bar. Then use the markers listed below.

Critical Markers

1. **Left shoulder**. acceptable names: L.SHOULDER LSHO
2. **Left lateral elbow.** acceptable names: L.ELBOW L.ELBOW.LATERAL L.ELBOW.LAT LELB
3. **Left wrist**:

   a. Lateral. acceptable names: L.WRIST L.WRIST.LATERAL L.WRIST.LAT LWRI

   or

   a. Radius. acceptable names: L.RADIUS LWRA

Semi-critical Markers

1. **Left medial elbow.** acceptable names: L.ELBOW.MEDIAL L.ELBOW.MED
2. **Left wrist**:

   a. Medial. acceptable names: L.WRIST.MEDIAL L.WRIST.MED

   or

   b. Ulna. acceptable names: L.ULNA LWRB

Right Hand

The right hand will always be included when the right arm is loaded, even if there are no markers on the hand. The presence of critical markers controls how the hand is scaled and what degrees of freedom it has. The right hand will be scaled separately from the right lower arm if the three critical markers listed below are present in the static trial. The individual finger gencoords will be added to the model if the three critical hand markers and the appropriate finger markers are present in the static trial.

Critical Markers

1. **Right thumb.** acceptable names: R.THUMB R.THUMB.M3
2. **Right middle finger.** acceptable names: R.MIDDLE.FINGER R.FINGER R.FINGER3.M3
3. **Right wrist:**

   a. Lateral. acceptable names: R.WRIST R.WRIST.LATERAL R.WRIST.LAT RWRI

   or

   b. Radius. acceptable names: R.RADIUS RWRA

Semi-critical Markers

1. **Right wrist**:

   a. medial. acceptable names: R.WRIST.MEDIAL R.WRIST.MED

   or

   b. Ulna. acceptable names: R.ULNA RWRB

Left Hand

The left hand will always be included when the left arm is loaded, even if there are no markers on the hand. The presence of critical markers controls how the hand is scaled and what degrees of freedom it has. The left hand will be scaled separately from the left lower arm if the three critical markers listed below are present in the static trial. The individual finger gencoords will be added to the model if the three critical hand markers and the appropriate finger markers are present in the static trial.

Critical Markers

1. **Left thumb**. acceptable names: L.THUMB L.THUMB.M3
2. **Left middle finger**. acceptable names: L.MIDDLE.FINGER L.FINGER L.FINGER3.M3
3. **Left wrist**:

   a. Lateral. acceptable names: L.WRIST L.WRIST.LATERAL L.WRIST.LAT LWRI

   or

b. Radius. acceptable names: L.RADIUS LWRA

Semi-critical Markers

1. **Left wrist**:
   a. Medial. acceptable names: L.WRIST.MEDIAL L.WRIST.MED

   or

   b. Ulna. acceptable names: L.ULNA LWRBb

Head

The head will always be included when the upper body is loaded, and the neck will contain three degrees of freedom. If the critical markers listed below are present in the static trial, the head will be scaled separately from the torso. Otherwise, the head will be scaled uniformly by the scale factor used for the Y (height) of the torso. If no markers (critical or optional) are included on the head in the static trial, then the degrees of freedom in the neck will remain fixed during imported motions.

Critical Markers

1. **Rear of head.** acceptable names: HEAD.REAR REAR.HEAD HEADREAR REARHEAD
2. **Top of head.** acceptable names: HEAD.TOP TOP.HEAD HEADTOP TOPHEAD
3. **Front of head.** acceptable names: HEAD.FRONT FRONT.HEAD HEADFRONT FRONTHEAD

The following optional markers are already defined in **mocap.jnt**. To use them, just put their exact names in your **EVaRT** project:

pelvis: R.Trochanter
L.Trochanter

thorax: Offset
Sternum
T10
CLAV
STRN
RBAK

cerv7: C7
C7 Spinous Process

head: R.Ear
L.Ear
RBHD
RFHD
LBHD
LFHD
HEDO
HEDP
HEDA
HEDL

clavicle_l: L.Clavicle

scapula_l: L.Scapula
L.Scapula.Top
L.Scapula.Bottom
L.Angulus Acromialis
L.Trigonum Spinae
L.Angulus Inferior

humerus_l: L.Bicep
L.Biceps.Lateral

ulna_l: L.Forearm

femur_l: L.Thigh
L.Thigh.Upper
L.Thigh.Front
L.Thigh.Rear
LTHI

tibia_l: L.Shank
L.Shank.Upper
L.Shank.Front
L.Shank.Rear
LTIB

foot_l: L.MedFoot
L.LatFoot

clavicle_r: R.Clavicle

scapula_r: R.Scapula
R.Scapula.Top
R.Scapula.Bottom
R.Angulus Acromialis
R.Trigonum Spinae
R.Angulus Inferior

humerus_r: R.Bicep
R.Biceps.Lateral

ulna_r: L.Forearm

femur_r: R.Thigh
R.Thigh.Upper
R.Thigh.Front
R.Thigh.Rear
RTHI

tibia_r: R.Shank
R.Shank.Upper
R.Shank.Front
R.Shank.Rear
RTIB

foot_r: R.MedFoot
R.LatFoot

Appendix I

Synchronizing Digital Video with EVaRT

Topic	Page
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Using EVaDV	I-2
Currently Open Known Issues	I-3

EVaDV Overview

EVaDV is a Digital Video (DV) capture application for use with Motion Analysis Corporation's **EVaRT** software for the synchronized capture of color video data on a separate Windows PC as ***.avi** files. You can directly transfer digital information back and forth between a DV camcorder and your computer with the use of the IEEE 1394 standard, also known as a Firewire or i.Link connection. If your computer does not come with this interface built into it, you will need to purchase an inexpensive card that provides the correct port.

You can run **EVaDV** on your local machine that has **EVaRT** running on it (not recommended) as well as with remote machines that are connected to digital video cameras.

Note: Any standard DV camcorder should be sufficient for use with the **EVaDV** software. All **EVaDV** testing and product development was done with a Sony™ DCR-TRV520 NTSC model DV camcorder.

System Requirements

Recommended Minimum Specifications

- **Microsoft Windows 2000** or **XP**
- 256 MB RAM
- 80GB (or more) free hard drive space (for captured files)
- CD-RW drive
- Ethernet card

Installation

We recommend you install the software into the **C:\Program Files\Motion Analysis\EVaDV** directory, but **EVaDV.exe** will run from any folder.

Note: No dongle or license file is required to run this application. But to collect synchronized color video (AVI files) in **EVaRT**, you need the [Reference Video 3.0] line in your mac_lic.dat license file.

Using EVaDV

Capturing Digital Video Using EVaDV

1. Launch **EVaDV.**
2. Select the desired camera/capture device from Camera dropdown. If there is a single video camera connected to the host system, **EVaDV** connects to this camera automatically.
3. Select a Capture Folder to indicate where captured files should be stored.
4. Select a Capture File to indicate the name of the file that will be created.
5. To begin recording, press the **Record** button (red circle). A red RECORD will display next to the player control panel indicating the system is recording, and a message will be displayed in the Message Bar indicating record start time.
6. To stop recording, press the **Stop** button. The red RECORD will disappear and a message will be displayed in the Message Bar indicating recorder filename, stop time, and any available stats.

Capturing Digital Video in EVaDV from EVaRT

Note: **[EVaXX]** indicates the host machine on which to perform the action.

1. Ensure the **EVaDV** host and the **EVaRT** host are connected to each other via a TCP/IP network connection.
2. **[EVaDV]** Launch **EVaDV** on the video capture host.
3. **[EVaRT]** Launch **EVaRT** on the **EVaRT** host.
   Note—launch order is unimportant, however if **EVaRT** grabs the camera/capture device first (i.e. displays color video window) **EVaDV** will not have access to the camera. **EVaRT** will grab the camera when you press the **F1** key in a capture window and release it when you select another key (**F2, F3**, etc.).
4. **[EVaDV]** Select the desired camera/capture device from Camera dropdown. If there is a single video camera connected to the host system, **EVaDV** connects to this camera automatically.
5. **[EVaRT]** Activate the Color Video (*.avi) checkbox in the **Motion Capture > Output** sub-panel. Press the **F1** key to show video and grab the DV camera.
6. **[EVaRT]** Press the **Record** button.

7. **[EVaDV]** On Record, **EVaDV** will record the file specified by **EVaRT** to the directory specified by **EVaRT** or, if not present, to the local Capture Folder. The Message Bar indicates the directory requested by **EVaRT**.
8. **[EVaDV]** On Record, A red "RECORD" will display next to the player control panel indicating system is recording, and a message will be displayed in the Message Bar indicating record start time.
9. **[EVaRT]** Stop recording by pressing either the **Stop** button or after reaching the duration specified.

Note: If you have more than one computer running **EVaRT** on the same network, the **EVaDV** software does not consume the plugin port (as does the streaming Alias/Motionbuilder online plugin, for example). The message about starting and ending the data capture is broadcast to the x.x.x.255 address which means that all computers connected can hear the message and start and stop the recording. So you should be able to connect as many **EVaDV** recorder-computers up as you need.

Note: You probably will not want the AVI files streaming across the network.

Note: When VC files are collected, AVI files are collected. If VC files are not collected, AVI files are not collected.

Note: You must have the color video window (F1 function) open in the **EVaRT** interface to record AVI files.

Suggestion for DV Camera Setup

Sony™ DV cameras have a setup mode called **FRAME/FIELD**. The **FRAME** setup mode works best as it eliminates the "motion blur" which results from the **FIELD** (also known as Interleaved) mode. On Canon™ DV cameras, you will want to select **MOVIE** mode.

Currently Open Known Issues

- Interface is evolving.
- Resizing video window by dragging corner can cause a hang-up. Stop, resize, play seems to work around this.
- File recompression functionality unstable with certain compressors.
- Multiple camera support is working, however certain cameras (Sony) seem to dislike it, and will give a "fail on run" message.
- Snapshot **.tga** image is incorrect.
- Only Type-1 (interleaved) AVI files are supported (import/export).

Known Graphic Card Issues

There is a known problem displaying the AVI files when a 3D window is displayed on a Windows XP system. The AVI file plays in a jerky motion and the screen is sometimes sliced into horizontal blocks.

This is a problem with Open GL and Direct X displaying at the same time. Right-click on your desktop, then select **Properties > Settings > Advanced > Troubleshoot**. Slide the Hardware Acceleration down a few points. Quit **EVaRT**, then re-launch. See if that fixes the problem. The settings depend on what your graphics card does and has for features that changes from one computer to another. If that does not fix the problem, try to slide the Hardware Acceleration to **None**. Quit **EVaRT** and then relaunch. If that still does not fix the problem, try to change some of the Open GL settings found under the name of your graphics card (found under the **Properties > Setting > Advanced** tab). Also, change the Vertical Sync setting to **On by Default** and restart your computer.

Appendix J

Using EVaRT with Jack Software

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Jack – Using the Motion Analysis Calcium Tracker Module	J-2
Jack5.0a Required & Recommended Marker Sets in EVaRT for Calcium Skeleton Generation	J-5

Introduction

Jack is an ergonomics and human factors product used in various industries to improve the ergonomics of product designs and workplace tasks. This software enables users to position biomechanically-accurate digital humans of various sizes in virtual environments, assign them tasks and analyze their performance. Jack (and Jill) digital humans can tell engineers what they can see and reach, how comfortable they are, when and why they're getting hurt, when they're getting tired and other important ergonomics information. This information helps organizations design safer and more effective products faster and for less cost. Ultimately, Jack helps companies bring factories on-line faster and optimize productivity while improving worker safety. For more information, please visit the UGS website at www.ugs.com.

Before You Start

Jack 5.0a does not need a new license file. It uses the same license as Jack 4.2. The license is based on your Ethernet card's Physical Address. To find it:

1. Select **Start > Run**. This command. brings up a DOS command window.
2. Type `ipconfig /all`
3. Find the line that looks like:
   ```
   Physical Address . . . . .   000-50-DA-8E-BC-BD
   <<--
   ```
4. Note yours and then contact UGS.

Installation of the Jack5.0a software requires very specific installation as per the instructions in the next section. If you deviate from the settings specified it will not launch.

The .jk.tcl file will not easily copy itself to a native windows environment. This will be fixed for the release version of Jack 5.0. The .jk.tcl acts as a launching tool for the Calcium plugin window. Currently, copying this file from a web-based browser (like Hotmail or Gmail) will allow you to save it as a .jk.tcl file (MS Windows thinks it doesn't have a filename). If you are using an MS product or Novell Webmail, it will try to rename it to .jk.tcl[1] and you cannot rename it. If you open the .jk.zip folder and extract the file, it will copy itself correctly, without appending the [1] to the end of the filename.

Installation Instructions

1. Download the latest Jack-5.0alpha from
   ftp://specialdevftp.eai.com/private/jack_dist/FordDW/Jim/Jack50a
2. Unzip each zip file to the **C:\Jack50a** folder.
3. Copy your Jack license file to the **C:\Jack50a\license** folder.
4. Copy the attached jk.tcl file to the **C:\Documents and Settings\<your_login_id>** folder.

Note: If you have a HOME environment variable set on your machine, copy the .jk.tcl file to your HOME folder.

5. To start Jack, double click on the **jack50.bat** file in the **C:\Jack50a** folder.
   - For debugging, you can use the **Start > Run…** command in a DOS window. Then cd \Jack50a and run the batch file: **jack50.bat.** This gives more information.

Jack – Using the Motion Analysis Calcium Tracker Module

Loading CalciumTracker module in Jack

1. Start Jack.
2. Click **Modules | Plug-ins...**
3. In the Add-On Modules Dialog, select the **CalciumTracker** module.
4. Click **Load** and **OK.**
5. Click **Modules | CalciumTracker | MotionAnalysis.**

-OR-

1. Start Jack (auto loading of Calcium Tracker occurs via the .jk.tcl script).
2. ***[Optional]*** If you are using .jk.tcl file, click **Modules | CalciumTracker Dialog.**

Connecting to MotionAnalysis

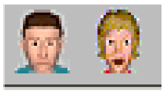
1. In the **MotionAnalysis-Calcium** dialog, click on the **Devices** tab. Enter the **EVaRT** or localhost computer name as the Host name, and then click **Connect.**
2. Check/Uncheck **Display Bodies** to turn on/off the visible bodies in Jack.
3. Set the Origin Rotation Check box to **ON**, select **X Rotation –90**, **Z Rotation –90**.

Auto-Scaling, Constraining and Positioning the Subject

1. Create a male or female Jack figure.

   This may be done by selecting either of the following buttons.

Figure J-1. Male or Female Selection Button



2. Click the **pick** button and select the subject from the scene.

   The subject turns yellow when it is picked. Left-click on the subject. The name “Human” should fill the blank box beside the pick icon.

3. Click on the **Subject** tab.
4. Have the actual subject in standing straight posture and click **Auto Scale.**
5. Click **Constrain.**
6. Click **Move**. Using the mouse in the Jack window, move the MA_ORIGIN figure to position the subject.

Creating Two Channel Eye View Windows (First Person) [OPTIONAL]

1. In the MotionAnalysis-Calcium dialog, click the **pick** button and select the subject from the scene.
2. Click on the **Eye View** tab. Click **Apply** (minimize all other windows). Note that the main Jack window is disabled. To enable, right - middle button on the TJ_Window and uncheck **Disabled.**
3. *[Optional]* You can change eye view window parameters.

Setting Up Collision Detection [OPTIONAL]

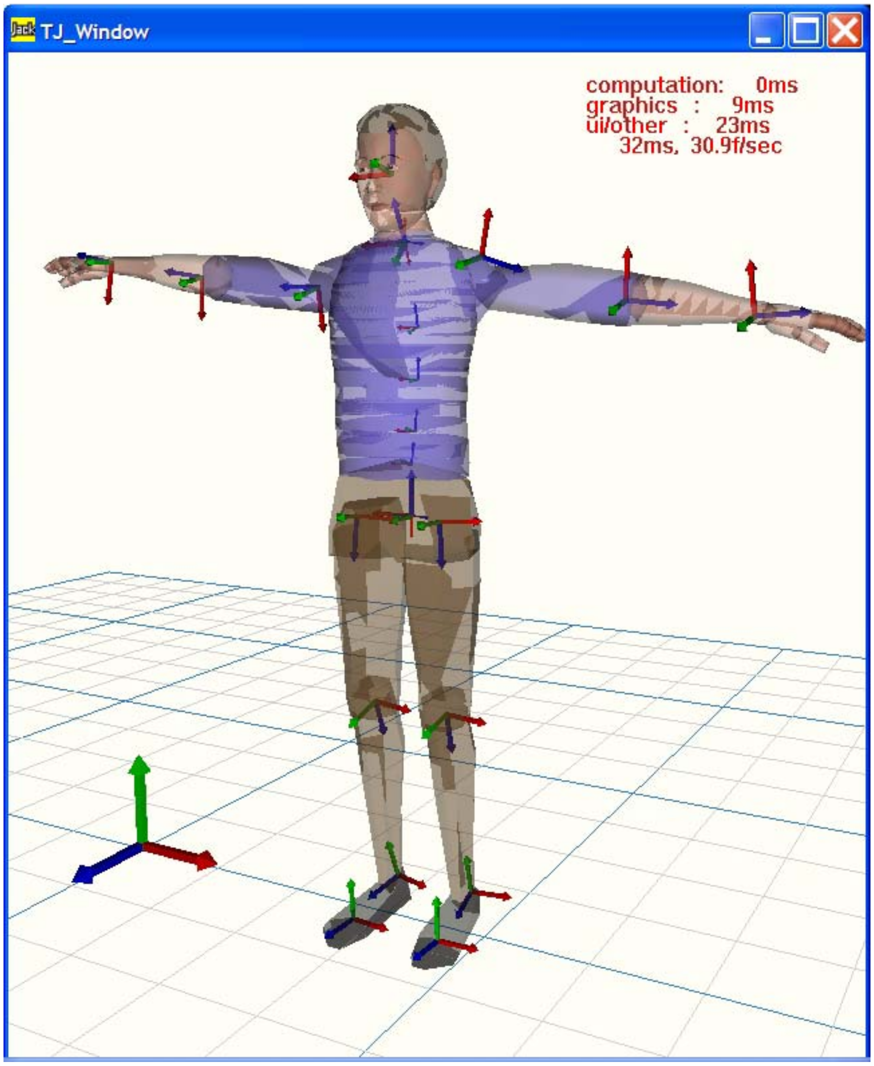
1. In the MotionAnalysis-Calcium dialog, click the **pick** button and select the subject from the scene.
2. Click on the **Collision** tab. Check the required segments and select an algorithm for the collision check. Then click **Apply.**

Note: You should have a scene loaded before you setup the collision detection.

List of Segments Required by Jack

1. Root
2. Head
3. Neck
4. Spine1/Spine2/Spine3/Spine4
5. LClavicle/RClavicle
6. LUpperArm/RUpperArm
7. LLowerArm/RLowerArm
8. LHand/RHand
9. LHip/RHip
10. LUpperLeg/RUpperLeg
11. LLowerLeg/RLowerLeg
12. LFoot/RFoot
13. LToes/RToes

Figure J-2. Jack Interface



computation: 0ms
graphics : 9ms
ui/other : 23ms
32ms, 30.9f/sec

Jack5.0a Required & Recommended Marker Sets in EVaRT for Calcium Skeleton Generation

Table J-1. Required markers for Jack 5 SIMM-OrthoTrak Model: 22 (absolute minimum)

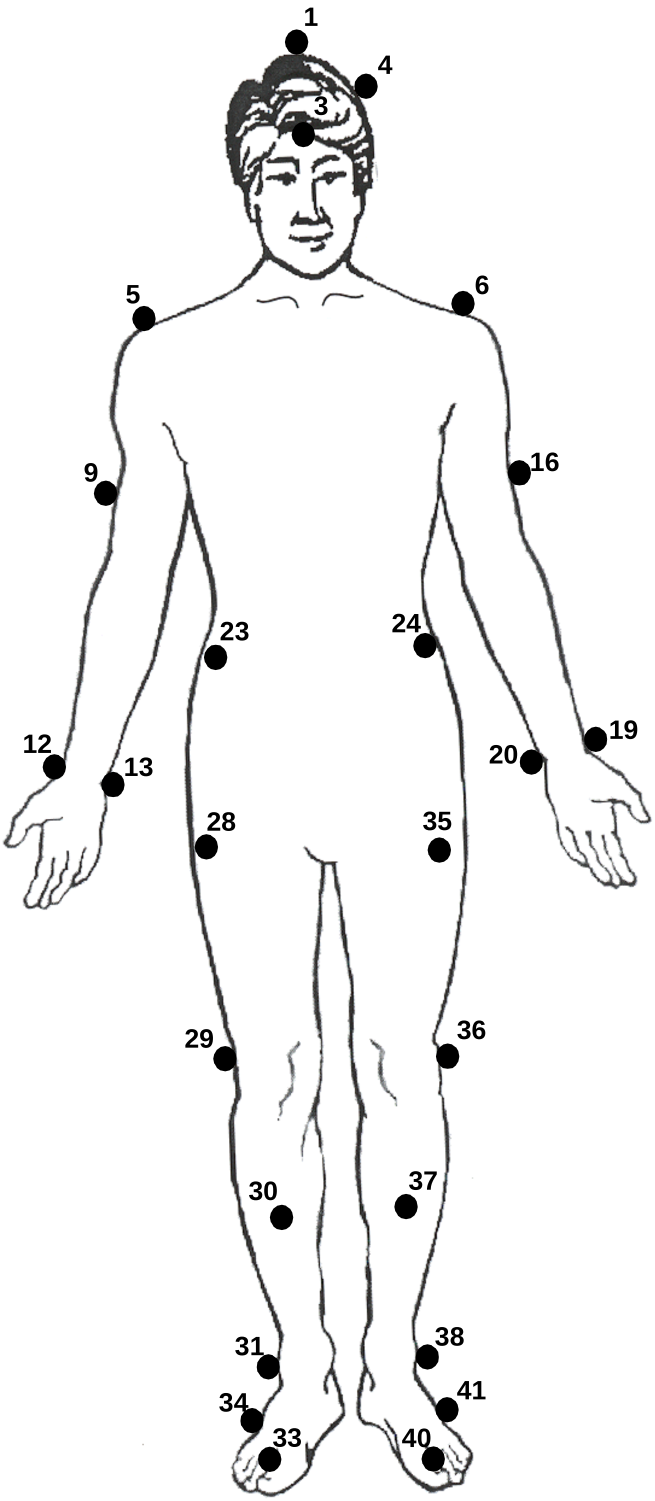
Markers	Location
R.Shoulder, L.Shoulder	markers on top of shoulder above shoulder joint
R.Elbow, L.Elbow	lateral side of elbow, on elbow hinge axis. On top of elbow with arms in T-pose position
Wrist has 2 options: R.Radius, L.Radius RECOMMENDED (on distal radius, thumb side of your hand), and R.Ulna, L.Ulna (on distal ulna, pinky side of your hand) -and/or- R.Wrist, L.Wrist: top of wrist	
R.ASIS and L.ASIS	Anterior Superior Iliac Spine
L.BackOffset	offset marker for asymmetry
Back of pelvis has 2 options: R.PSIS and L.PSIS: RECOMMENDED Posterior Superior Iliac Spine -and/or- V.Sacral (All 5 is RECOMMENDED: ASIS, PSIS, V.Sacral)	
R.Knee and L.Knee	lateral knee, close to knee axis
R.Ankle and L.Ankle	lateral ankle, on fibular malleolus
R.Heel and L.Heel	heel, at same height as toe markers
R.Toe and L.Toe	toe markers, center of foot at proximal base of toe joint

The following markers are a recommended marker set only. These incorporate the above markers, include some additional markers, and match the data set Jack5_41Markers_AutoScale.prj in the Sample Data files.

1. Top.head
2. Back.Head
3. Front.Head
4. L.Head_Offset
5. R.Shoulder
6. L.Shoulder
7. Neck
8. L.BackOffset
9. R.Bicep
10. R.Elbow
11. R.ForeArm
12. R.Radius
13. R.Ulna
14. R.Thumb
15. R.Pinky
16. L.Bicep
17. L.Elbow
18. L.Forearm
19. L.Radius
20. L.Ulna
21. L.Thumb
22. L.Pinky
23. R.ASIS
24. L.ASIS
25. R.PSIS
26. L.PSIS
27. V.Sacral
28. R.Thigh
29. R.Knee
30. R.Shank
31. R.Ankle
32. R.Heel
33. R.Toe
34. R.Foot
35. L.Thigh
36. L.Knee
37. L.Shank
38. L.Ankle
39. L.Toe
40. L.Heel
41. L.Foot

Jack 5 Marker Set

Figure J-3. Front View


1
4
3
5
6
9
16
23
24
12
13
20
19
28
35
29
36
30
37
31
38
34
41
33
40

1 - Top.Head

3 - Front.Head
4 - L.Head_Offset
5 - R.Shoulder
6 - L.Shoulder

9 - R.Bicep

12 - R.Radius
13 - R.Ulna

16 - L.Bicep

19 - L.Radius
20 - L.Ulna

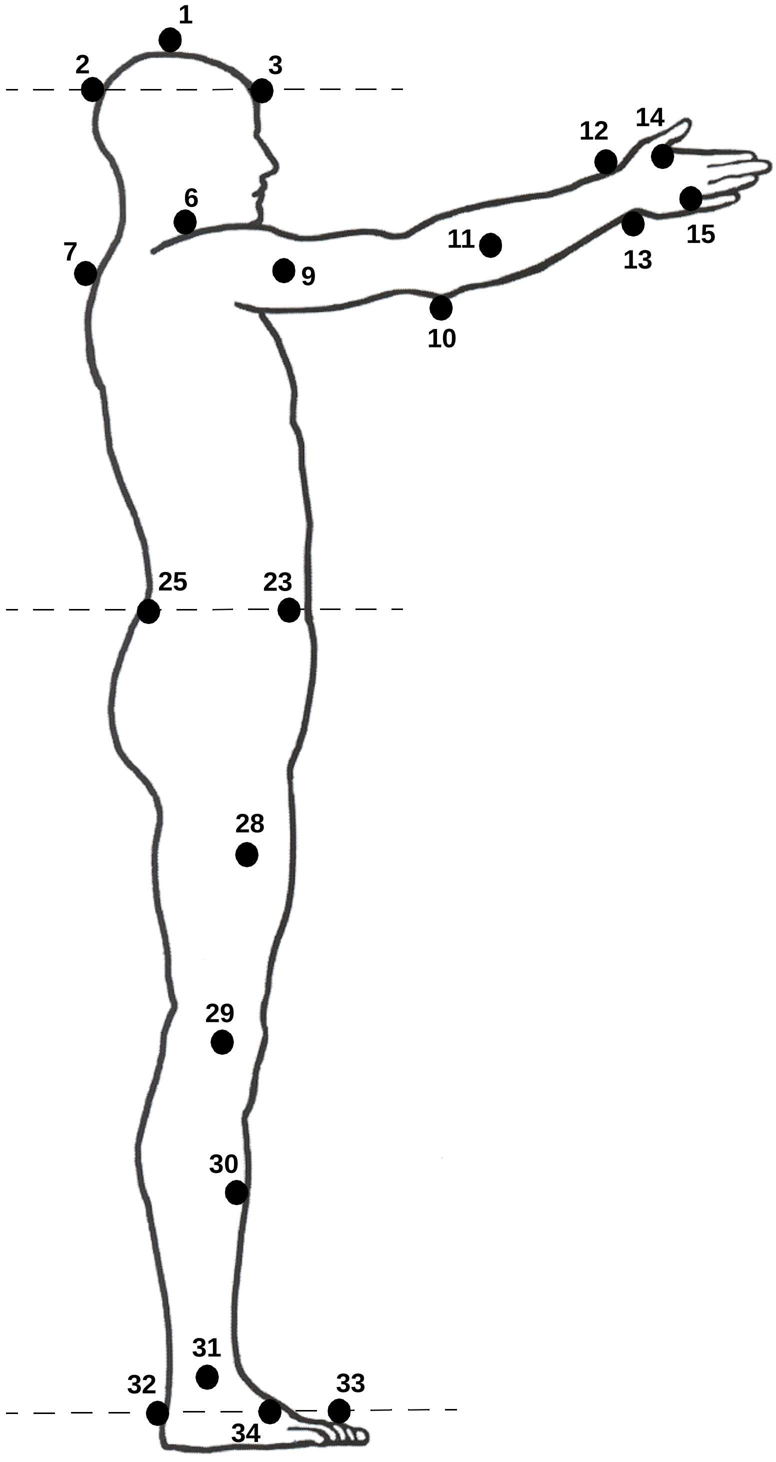
23 - R.Asis
24 - L.Asis

28 - R.Thigh
29 - R.Knee
30 - R.Shank
31 - R.Ankle

33 - R.Toe
34 - R.Foot
35 - L.Thigh
36 - L.Knee
37 - L.Shank
38 - L.Ankle

40 - L.Toe
41 - L.Foot

Figure J-4. Right Side View


1
2
3
14
12
6
7
9
11
15
13
10
25
23
28
29
30
31
32
33
34

1 - Top.Head
2 - Back.Head
3 - Front.Head

6 - L.Shoulder
7 - Neck

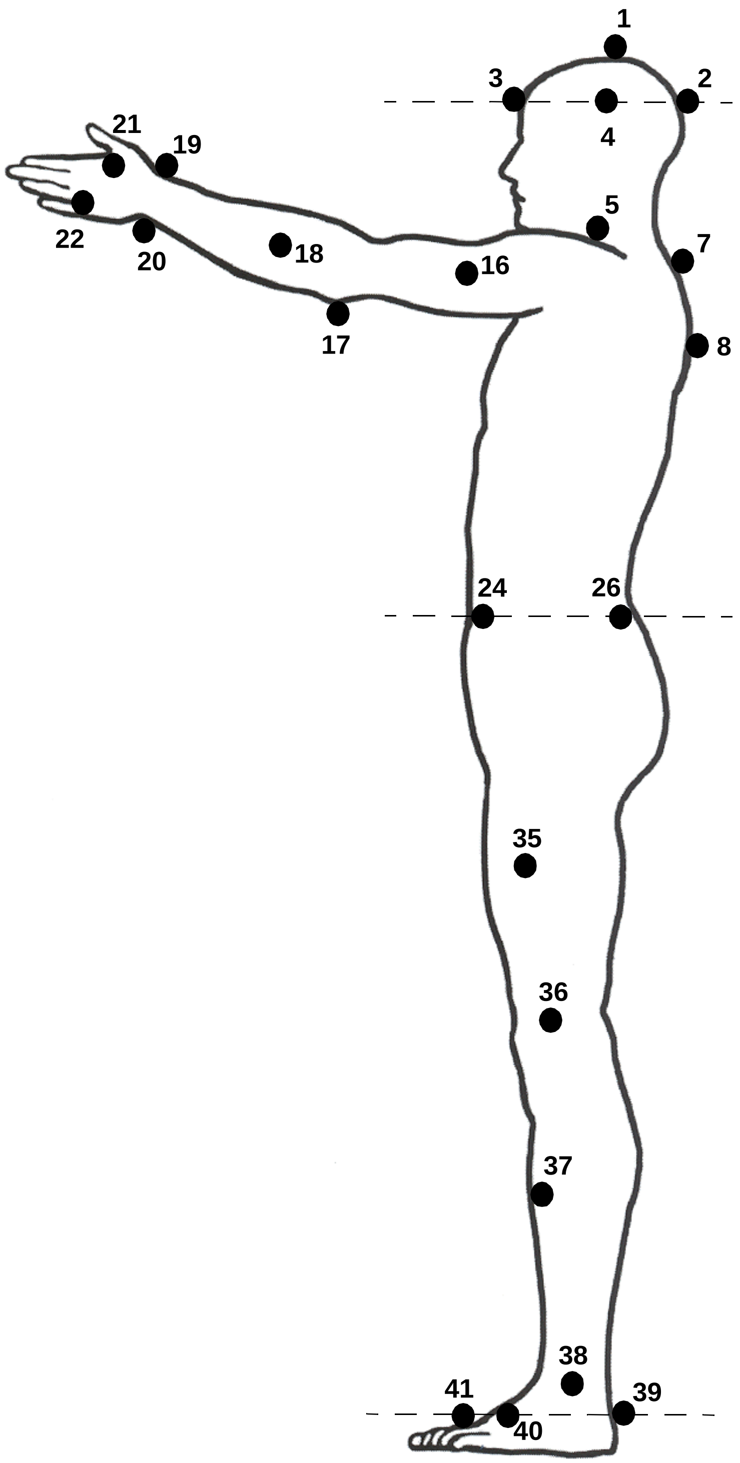
9 - R.Bicep
10 - R.Elbow
11 - R.Forearm
12 - R.Radius
13 - R.Ulna
14 - R.Thumb
15 - R.Pinky

23 - R.Asis

25 - R.Psis

28 - R.Thigh
29 - R.Knee
30 - R.Shank
31 - R.Ankle
32 - R.Heel
33 - R.Toe
34 - R.Foot

Figure J-5. Left Side View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1 - Top.Head
2 - Back.Head
3 - Front.Head
4 - L.Head_Offset
5 - R.Shoulder

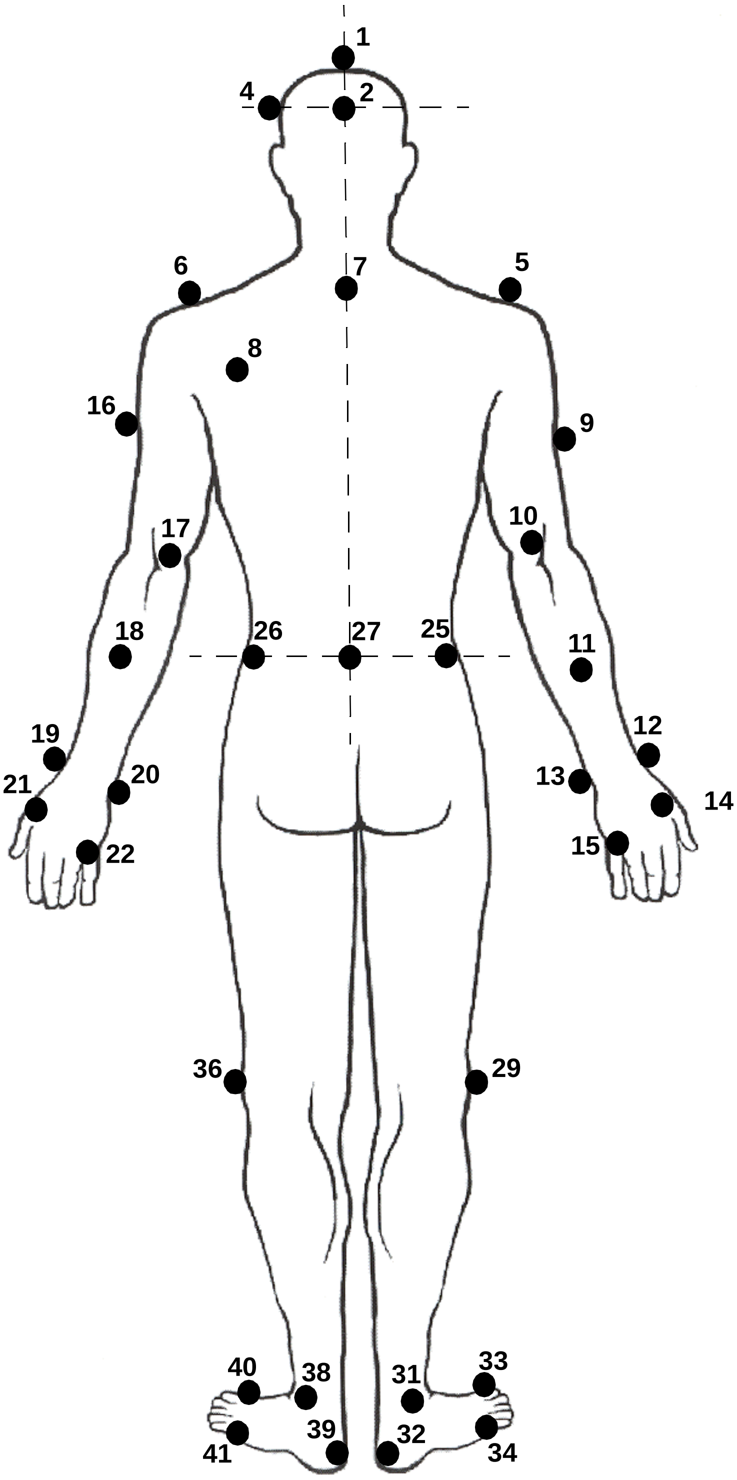
7 - Neck
8 - L.Back_Offset

16 - L.Bicep
17 - L.Elbow
18 - L.Forearm
19 - L.Radius
20 - L.Ulna
21 - L.Thumb
22 - L.Pinky

24 - L.Asis
26 - L.Psis

35 - L.Thigh
36 - L.Knee
37 - L.Shank
38 - L.Ankle
39 - L.Heel
40 - L.Toe
41 - L.Foot

Figure 16. Rear View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1 - Top.Head
2 - Back.Head

4 - L.Head_Offset
5 - R.Shoulder
6 - L.Shoulder
7 - Neck
8 - L.Back_Offset
9 - R.Bicep
10 - R.Elbow
11 - R.Forearm
12 - R.Radius
13 - R.Ulna
14 - R.Thumb
15 - R.Pinky
16 - L.Bicep
17 - L.Elbow
18 - L.Forearm
19 - L.Radius
20 - L.Ulna
21 - L.Thumb
22 - L.Pinky

25 - R.Psis
26 - L.Psis
27 - V.Sacral

29 - R.Knee

31 - R.Ankle
32 - R.Heel
33 - R.Toe
34 - R.Foot

36 - L.Knee

38 - L.Ankle
39 - L.Heel
40 - L.Toe
41 - L.Foot

Appendix K

Questions and Answers for Specific Applications

Question *Does **EVaRT** require a specific order for markers and linkages?*

Answer For the identification of markers to work swiftly in real-time the order of marker definitions is important. You should follow these rules.

1. Markers should be ordered such that each successive marker builds the character top to bottom through linkages (i.e. Head to Neck, down one arm, then down the other, down the torso to the hips, down one leg, then the other). Do not backtrack.
2. If the first markers are linked into a stiff triangle, marker identification will be swift. For this reason, the head markers should always be first. Linkage order may affect the rectify process. For the head, a linkage order of 1-2, 1-3, and 2-3 works well.

Question *How can I prevent ghost markers from appearing?*

Answer

1. Ghost markers may appear if the Max. Residual value is set too low. This parameter is set in the tracking function in the Motion Capture mode (except for centroid function instead of tracking).
2. Set the minimum number of cameras to 3.
3. Increase the minimum number of lines per marker

Question *How do I control the length of a recorded file in **EVaRT**?*

Answer All the recording options are set in the Output function in the Motion Capture mode.

When the record button is clicked using the trigger or the mouse, a new file is recorded and saved with the name, directory, and output type(s) you have specified. The recording will stop when either:

- the duration in seconds is reached
- the **Stop** button is clicked using the trigger or mouse

The default duration is 60 seconds. If you always want to control the end of the take with the trigger or mouse, we recommend setting the duration to a number that is higher than the trials you usually capture such as 10 minutes (600 seconds).

Question *Can **EVaRT** be used in a large capture volume (for example 50'x50', 50 cameras)?*

Answer If care is taken during setup, motion capture will work well in a large volume. The four areas requiring attention are:

1. **Camera Setup**—Are your cameras covering your volume efficiently? Are you using an overlapping volume setup? If not, you may have too many cameras seeing the same area. Over coverage can result in an over abundance of data, slowing the system down.

Note: Try to have no more than three cameras see any given area of the capture volume from one direction and 10 to 12 cameras total.

2. **Calibration**—Tracking residuals should be below 2.0 mm. If not, try raising the Max. Residual value. Too low a value may cause ghost markers to appear.
3. **Template**—Verify that marker identity is being performed quickly. Click the **Reset IDs** button several times while the actor is in the capture space and see if there is a lag in acquiring marker identification. If there is a lag, you may need to create a better template. Verify that the first three markers are the head markers and that the first three links form a rigid triangle. Finally, verify that remaining link definitions flow down the body following the marker definitions.
4. **Frame to Frame Rectifying**—This is mainly influenced by your 3D data quality and tracking parameters. Too many extra, stretchy linkages can cause problems here.

Question *Can I use MoCap Solver, Si 2.0, or Calcium in **EVaRT**?*

Answer Yes. Export a MOD file from Si/Calcium and name it the same as the project file. Select **Model Edit > Tree View** and then in the **Setup > Misc** sub-panel, select **Calcium Solver** in the Skeleton Engine field.

Question *What is the order of the data in the TRC or TRB files when you use MTOs for tracking?*

Answer The resulting **.trc** file from MTO tracking should match the marker order of the resulting "Merge MarkerSets" operation.

Question *If I have a Solver skeleton setup from **EVa 6.x**, can I use it in **EVaRT**?*

Answer Yes, if you go to the **Setup > Misc** sub-panel and in the Skeleton Engine field, you check **Calcium Solver.** in **EVaRT.** You must also copy the MOD file into your current project folder with the same name as your current PRJ file.

Question	*If I have the* **EVa 6.X** *Solver setup, can I get an HTR file from* **EVaRT***?*
Answer	Yes. Select the Calcium Solver Skeleton Engine button (Bone button, in lower left of the Post Process dashboard), then select **File > Export HTR File....**
Question	*What are the tradeoffs in capturing at 120 fps or faster or slower with Eagle cameras?*
Answer	With the older analog cameras, there were tradeoffs in image quality as the frame rate went up. With the Eagle cameras, we see no degradation AT ALL with the higher frame rates, which is great for high speed captures. The images are all taken off of the Eagle sensors in 2 msec which corresponds to the 500 fps. Waiting longer between frames does not degrade or enhance the image quality. The only considerations are Ethernet bandwidth (not generally a problem), disk space used, and time to process (or post-process) the raw VC files.
Question	*Are there any rules that should be followed when deciding which camera should be set as "Master"?*
Answer	Any camera can be master. If you have an A-D system, the master camera must be connected to it using the A-D sync cable.
Question	*When you see a marker in the 2D display, are you simply seeing a digital representation of what the camera sees at the CCD, or are any of the tracking parameters incorporated into determining whether the system "sees" a marker (i.e. marker size, centroid parameters, etc.)?*
Answer	The black data is the raw edge data, affected only by the lighting and the Threshold. The red dots (lens corrected and/or not) are the calculated centroids. To calculate a centroid, there are two main things: 1) Min Lines per Marker (usually set to 2 or 3 lines), 2) Max. lines per Marker (usually set to a BIG number like 100), and Shape Analysis (None, Normal or Weak), normally to Normal. But sometimes it is set it to None if it is tossing out centroids, like during a L-Frame seed calibration.
Question	*Can you connect 7 or 8 cameras to an EagleHub? We tried connecting 8 cameras to an EagleHub2 and the data transfer to the gigaswitch became quite unstable. Note that this pertains to the older 8-port EagleHubs only (not the 12-port EagleHubs).*
Answer	There are only 8 useful ports on an older model EagleHub, which means 7 cameras can be connected to the EagleHub, and one more is used for the uplink to the Network Interface Card (NIC). An eighth camera can be connected directly to one of the remaining open port son the NIC using a patch cable.

Question

Is there a way to have two templates for two people in the project that identify them both in real time at once, rather than using one huge template that includes everything?

Answer

This is the MTO (Multiple Tracking Object) item. Refer to "Multiple Tracking Objects" on page 9-7.

Question

What does the extend template option do?

Answer

Extend Template adds new linkage stretch to the existing template if you need it. For example, you can make a one frame template, ID some motion, then you can extend the template so that it knows about the new motion linkage stretches as well as the old ones.

Question

What are the latest specifications for the Eagle system performance?

Answer

From the 5 person Eagle camera data included in the **EVaRT** release package under the Samples folder:

- Trial: FivestarsAgainandAgain.VCX: 1800 Frames, 120 Frames/sec. per the EVaRT software.
- Biggest VC file: 3900 KB (highest data rate), Smallest VC File: 1100 KB, Avg. VC. size about 2500 KBytes.
- Data rate per Eagle camera: Max size file: 3900 KBytes X 120 Frames/sec X 1/1800 Frames = 260 KBytes/sec or about 2600 Kbps (kilobits/sec) or 2.6 Mbps or about 2.6% of the 100 Mbps Ethernet or about 0.26% of the 1000 Mbps Ethernet
- Avg. size file: 2500 KBytes X 120 Frames/sec X 1/1800 Frames = 166 KBytes/sec or about 1660 Kbps or about 1.6% of the 100 Mbps Ethernet

So, what does this mean for your 12 Camera Setup?

For a 5 person Eagle camera capture, with an average data rate for 120 Hz capture per camera, it works fine (about 1660 Kbps X 12 cameras = 19,920 Kbps or about 20% of the available Ethernet bandwidth). We used a Gigabit Ethernet NIC and Switch for our 24 camera setup. That used about 4% of the 1000 Mbps Ethernet, but would have been 40% of the 100 Mbps Ethernet, which could result in lost packets. The **EVaRT** software is robust enough to deal gracefully with lost packets by ignoring the empty frames and continuing with the capture.

Another dataset in the Samples folder, **Eagles Face and Body**: Eagle one person, 60 Frames/sec, 400 Frames, 300-600 KBytes per camera, average maybe 450 KBytes (450 KBytes X 60 Frames/sec X 1/400 Frames = 68 KBytes /sec or about 680 Kbits/sec or about 0.7% of the 100 Mbps Ethernet).

For your 12 camera setup, this would be: 680 Kbps X 12 cameras = 8160 Kbps or about 8% of the 100 Mbps Ethernet.

Question	*Why is there is a problem displaying the AVI files when a 3D window is displayed on a Windows XP system? The AVI file plays in a jerky motion and the screen is sometimes sliced into horizontal blocks.*
Answer	This is a problem with Open GL and Direct X displaying at the same time. Right-click on your desktop, then select **Properties > Settings > Advanced > Troubleshoot**. Slide the Hardware Acceleration down a few points. Quit **EVaRT**, then re-launch. See if that fixes the problem. The settings depend on what your graphics card does and has for features that changes from one computer to another. If that does not fix the problem, try to slide the Hardware Acceleration to **None**. Quit **EVaRT** and then re-launch. If that still does not fix the problem, try to change some of the Open GL settings found under the name of your graphics card (found under the **Properties > Setting > Advanced** tab). Also, change the Vertical Sync setting to **On by Default** and restart your computer.
Question	*We came across a problem while in a two person w/ prop motion capture session. Whenever we recorded a motion, the recorded trc file would be missing a good portion of the marker data. Any idea why the data would just disappear?*
Answer	This is most likely cause by insufficient marker slots. The default marker slot setting is 192. In your case, you should increase the value. The marker slot setting maybe adjusted under **Setup > Misc**.
Question	*We are only using 93 markers (40 per actor, 5 per prop, and 3 for the ball). Shouldn’t 192 marker slots be enough?*
Answer	Not necessarily. You should always have at least twice as many marker slots then actual markers. The number of slot is dependent on the tracking parameters settings. Each snippet of trajectory requires its own slot and different parameter values will create different sets of trajectories.
Question	*How will I know if I need more marker slots?*
Answer	After loading the file (trb/trc). In Post Processing Mode, scroll down the unnamed marker list (u_marker). If the all the slots are filled then you should increase the number of marker slots.
Question	*I just made some changes to my project file, but I do not want to recapture the entire motion list over again. Is there any way to rebuild the trb/trc data from the VC files?*
Answer	Yes. You can re-record the tracks files using the updated set of parameters in **EVaRT**. First load the VC files. Then go to the **Motion Capture > Output** panel. Select to export a trb or trc file, you have to select the option **OK to Overwrite** if the tracks file already exists. Click on **Record**. The recording will automatically stop at the end of the VC file as long as the option “Loop Raw Files” is not checked (in the **Setup > Misc** panel). If it is checked then you will have to stop it by pressing the **Stop** button (same as the Record button, it changes name during the recording).

Question	*Our templates in EVaRT are always either extremely good or extremely poor. Can you give us some time so we can get a consistently good template each time?*
Answer	The first step of the process is to collect both an init pose and a ROM(range of motion) for the actor. Do a manual identification of the makers in the init pose (T-pose or A-pose). Use this to create your template. You should next be able to ID the first frame of the ROM (which should be a T-Pose) and do a Rectify through the whole ROM. Once the ROM has been completely identified, save the changes and then use Extend Template from the Create Template Dialog box. The next step is to process all the easier motions. This way you can use these motions to extend your template further which will allow you to have a more complete template by the time you need to track the harder motion files.

Appendix L Useful Blank Forms

Topic	Page
Motion Capture Log	L-2
Human Body Outline—Front	L-3
Human Body Outline—Side	L-4
Human Body Outline—Back	L-5

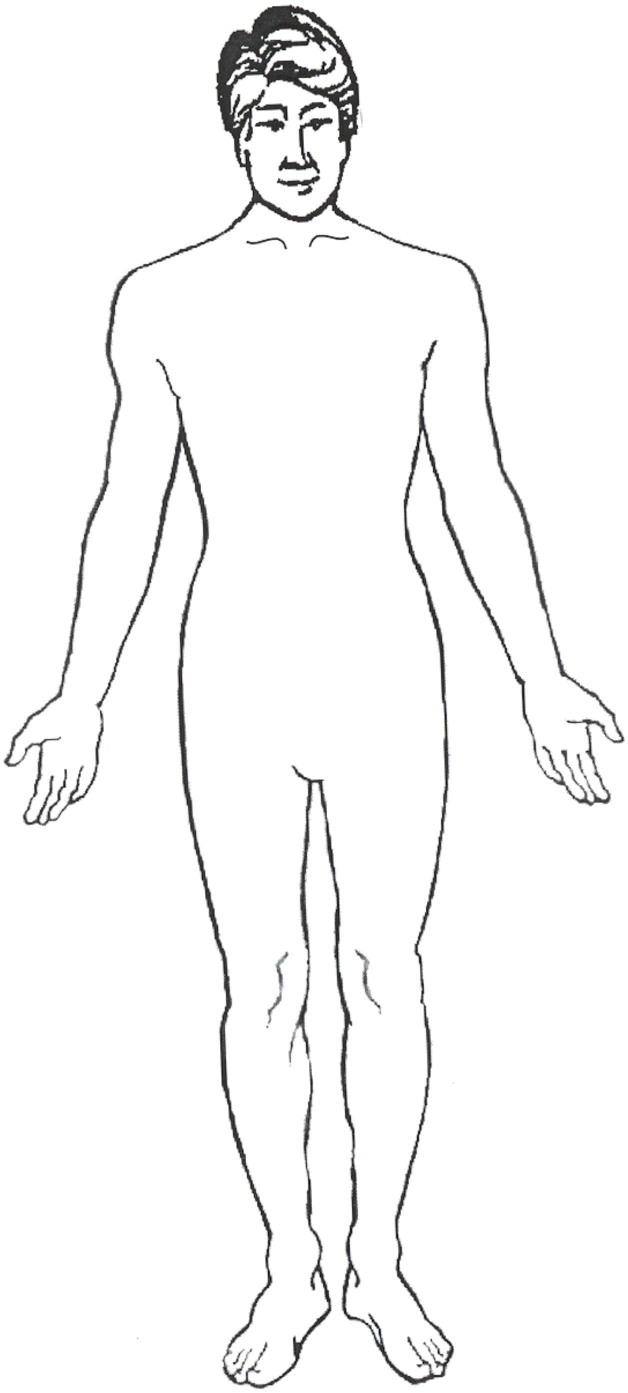
The following blank forms may be useful to prepare for and document a motion capture session. Feel free to make copies as needed.

Motion Capture Log

Date ______/_____/________			Client ____		
Take #	EVaRT Filename	# Seconds	Ref. Video Counter	Comments	Results

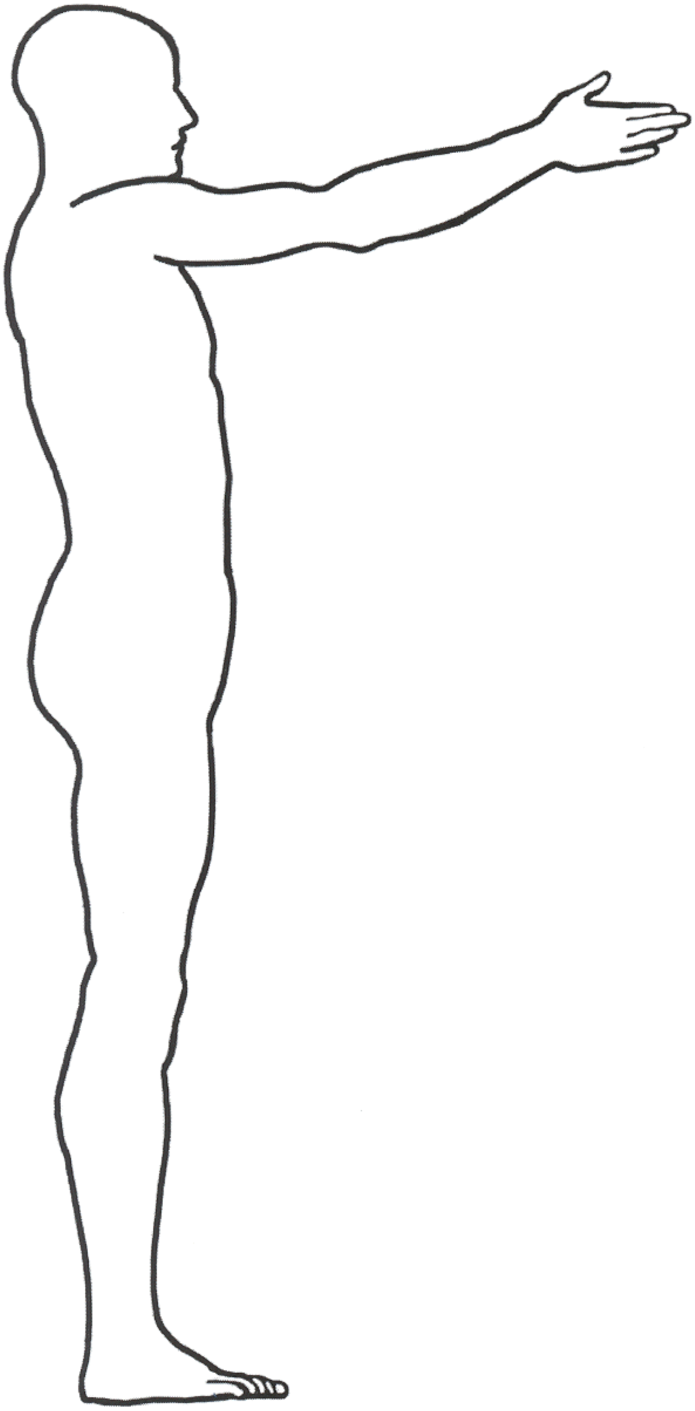
Human Body Outline—Front

Project____Date______/_____/____



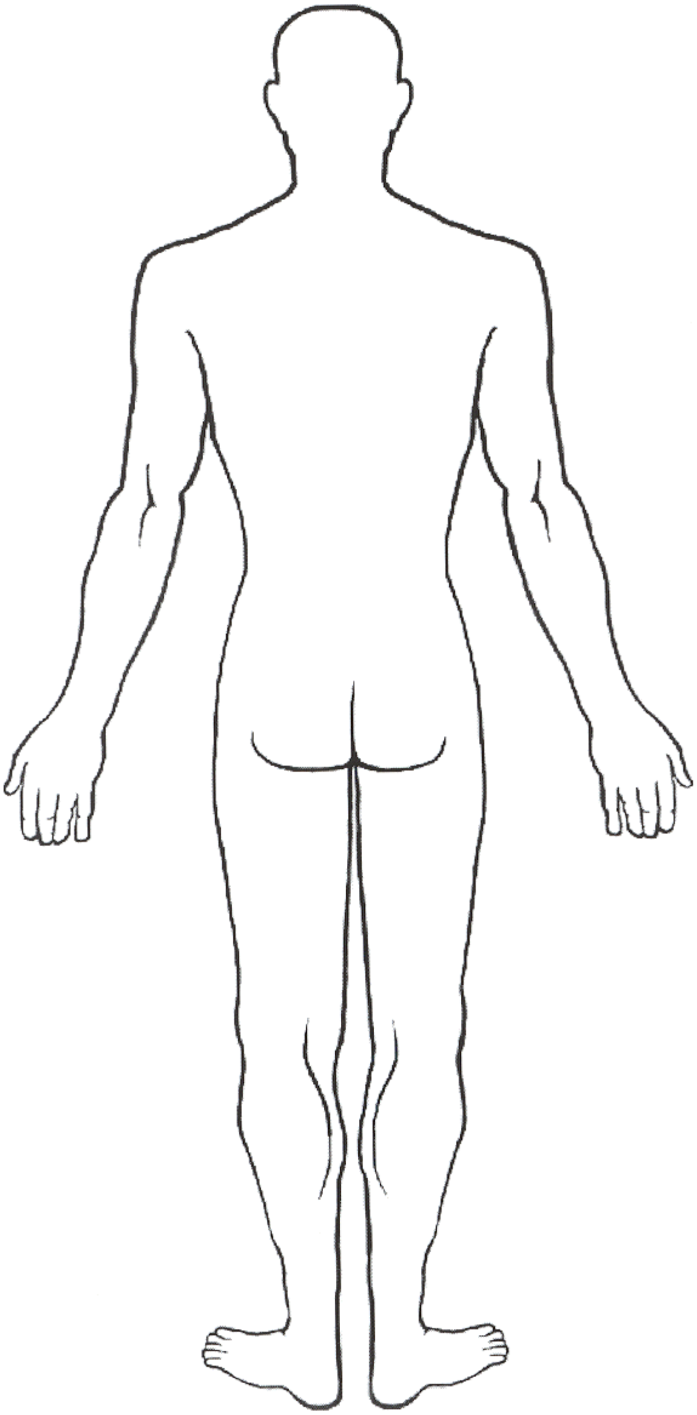
Human Body Outline—Side

Project____Date______/_____/____



Human Body Outline—Back

Project____Date______/_____/____



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